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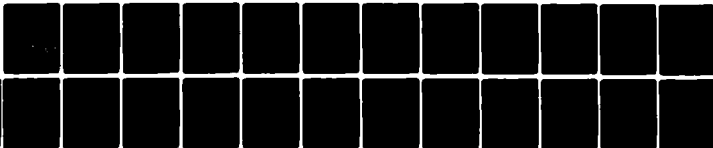
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edited by Francis A. Richards and Don J. Peters

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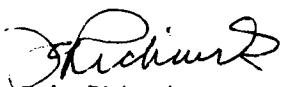
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F.A. Richards  
Chief Scientist



L.B. Sykes  
Captain, USN  
Commanding Officer

CDR R.F. Ashford  
Dr. D.R. Barr  
Dr. N.A. Bond, Jr.  
LCDR R.W. Booker

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## BEHAVIORAL SCIENCES

### LANDING AIDS RESEARCH AT THE UK ROYAL AIRCRAFT ESTABLISHMENT

The visual cue requirements for ordinary fixed-wing landings are well known. The accepted wisdom is that perspective and dynamic "center of expansion" or aimpoint events are the major cues used for lining up the final approach. The pilot sees the trapezoidal runway outline develop as the turn onto the final approach is completed; when fairly well lined up, he may fixate an aiming point on the runway. Either the observation of no relative motion of that point or an apparent expansion of the visual field surrounding the point will indicate that the aircraft is now heading directly for the point. Indeed, the pilot can often "fly the point" as the approach continues. When the aircraft crosses the threshold, close-up textural and motional parallax cues are employed for roundout and flare. For some years the visual-glide-slope indicators were designed to bring the aircraft to a point about half a mile from touchdown and 200 ft from the ground; from there, it was expected that the pilot would measure the close-up angular velocities of near and far objects to estimate the sink rate. To get good exponential flares, flight instructors would often tell their students to look down the runway during the flare; presumably, following this advice would facilitate sink rate judgments and would also provide an excellent roll reference to the horizon. (If very advanced cockpit instrumentation is feasible, the presence of several localizer "T-bars" in a cockpit instrument is a powerful augmenting cue. Research by Stanley Roscoe [New Mexico State Univ., US] has shown that when the T-bars are arranged like a highway in the sky (Fig. 1) the pilot is "unburdened" and has only to fly down the T-bars to a good landing.)

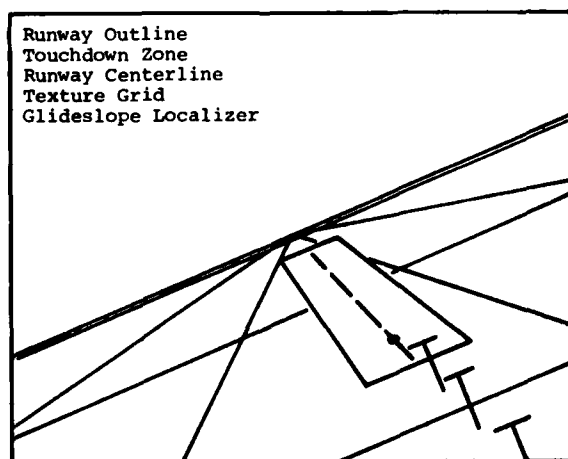


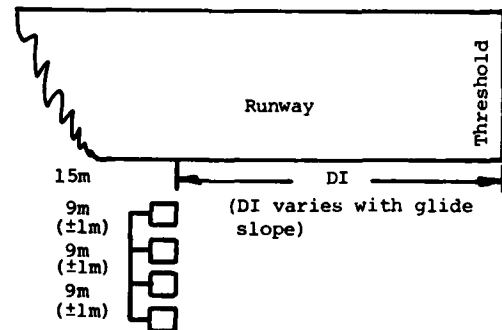
Fig. 1

Today the landing requirements are often more severe than the old half-mile-at-200-ft operating condition. On heavy jets, engine response times are often longer, and with

slower speeds during landing the aircraft is more likely to incur wind-shear phenomena. At the Royal Aircraft Establishment (RAE), Farnborough, UK, there has been a continuing program of research on landing aids. The Precision Approach Path Indicator (PAPI) project is a good example of RAE systems analysis and evaluation. It shows what can be done with ingenious ground-based aiding lights, with no complex electronics in the cockpit.

The RAE formulated fully a dozen requirements for an operational PAPI system: "natural" display of position and rate information, provision for roll reference, easy resetting for nonstandard glide slopes, and so forth. There were also practical necessities for simplicity, economy, stand-alone operability, portability, and ruggedness.

Present PAPI hardware uses two-color light projector units. Four of the units are mounted on each side of the runway. Each unit has three projectors inside, and these are arranged so that the emerging light beam is white at the top and red at the bottom. The setting angles of the four units are calibrated to a 9-m interval spacing between units, as shown in the plan layout in Figure 2. An ideal path down the glide slope is thus defined to be midway between the beams emanating from the two center units. The array of lights will therefore appear to the pilot on a good approach as two whites and two reds. An all-white display indicates the aircraft is too high; all red signifies a too-low approach vector. The PAPI projector optics yield a very crisp transition (<3 minutes of arc) from red to white, and this phase change is reportedly very conspicuous to the observer.



TYPICAL WING BAR INSTALLATION (ONE SIDE OF RUNWAY)

Fig. 2

PAPI has been evaluated on several kinds of aircraft, including jet transports, military fighters, and helicopters. Graphics of actual-vs-ideal approach paths show remarkably accurate altitude control; one data set for a standard 3° glide path had a maximum altitude deviation of 12 ft, and this one "outlier"



occurred some 400 m from runway threshold, so there was adequate time to recover. The system display must be fairly natural; one pilot used it successfully on approach without knowing it would be there and without being told what the display colors meant!

Siting and equipment characteristics for PAPI have been experimentally determined. The key color-transition requirement of a few minutes of arc can be met by essentially off-the-shelf optical and illuminating components. Early field work set the minimum on-path signalled altitude at 30 ft above the runway, but further trials proved that the system can work aircraft at much lower levels. Thus, for light aircraft with eye-to-wheel heights of 7 ft, the projector units can be set so that the lowest on-slope signal transition (from two red-two white to three red-one white) is at 14 ft. Isocandela test curves show that the illumination from the light sources is 50% or more if the viewing position falls inside a cone within 10° or so of the desired path; this means that the light doesn't dim appreciably if the vehicle stays inside a reasonable cone, so there is little danger of completely losing the PAPI signal.

Another set of RAE projects is directed to helicopter landing aids. A recurrent problem in helicopter landings is foggy conditions. Fog density varies sharply with height; for example, a slant visibility of 700 m at ground level can be half that a short distance above ground. RAE investigators have now formulated a mathematical model that can predict what a helicopter pilot can expect to see during final approach--given the instantaneous parameters on fog, glide-slope angle, pilot field of view, and ground lighting. Expectation profiles can be computed with the model; as one illustration, it can predict the distance (from touchdown) at which the pilot will first see the runway lights. These output profiles can be computed for any chosen environment and certainty level; a "2½%" profile, for instance, might give the expected results under the constraint that "fog is worse than this only 2½% of the time"; or a more lenient criterion can be selected wherein average fog density is assumed. For runway design and setup, it is also possible to compute what will happen, say, regarding the range of furthest light seen by a pilot if runway light power is reduced by some percentage (the effects are surprisingly small for moderate glide slopes and moderate fog parameters.) Given such a simulation model along with fog statistics, it is even possible to optimize a landing port configuration. Alternative designs within the constraints are run and the best one chosen. In simulation runs that have been completed, there were occasional discontinuities and sharp inflection points caused by such factors as the lights on the ground and the fog densities. Major benefits of such models are the demonstration of non-compensatory factors and the exploration of

tradeoffs within the ranges where compensation can take place.

It seems likely that the next generation of fixed-wing and rotary-wing aircraft will have advanced glide-localizer electronics and that such equipment will permit routine landing by means of T-bars or similar dynamic displays. There will always be a place for simple and rugged landing aids, however, and the RAE systems projects are at the forefront in this important R&D area.

*Nicholas A. Bond, Jr.*

ONR London

### PEACETIME SUICIDE IN THE MILITARY

Suicides sometimes make up a significant fraction of deaths in a peacetime military organization. In the 20 years between 1957 and 1978, for example, a total of 14,678 soldiers in the West German Army died from all causes, and of these, 1,509 or about 10% were suicides. At first glance that appears to be a high rate, but when compared to suicide in the old Prussian Army or in the World War II Wehrmacht the present rate is quite low. It is also lower, by about half, than the suicide rates of comparable civilian young men in West Germany. The figures come from a NATO report by M. H. Flach of the Dezernat Wehrpsychologie, Streit-Kräfteamt, Bonn. Flach's analyses not only document the facts of suicide in the West German army, they also look into the correlates of suicidal behavior and propose a transaction-coping model for dealing with it.

Flach's tables show that the annual suicide rate has been remarkably constant over the years and has stabilized at about 17.5 deaths per year per 100,000 men. The frequency of suicide attempts per year, however, has shown a steady rise, from about 46/10<sup>5</sup> in 1957 to 228/10<sup>5</sup> in 1978, nearly a fivefold increase. In the civilian domain, nobody knows the exact ratio of suicide attempts to completed suicides because of concealment of attempts and generally incomplete records; various experts have given estimates ranging from 5:1 up to 20:1. For military personnel, concealment of suicide attempts is far less likely, so it is interesting that the ratio reported for the West German army was about 8 to 1 for the period 1957 to 1978 and about 14 to 1 for the most recent years. Happily enough, this is about the middle of the range predicted by experts.

Self-destructive methods used by soldiers in completed suicides and in suicide attempts tend to be quite different. About two-thirds of real suicides in Flach's data base used hard methods such as guns and hanging, but the attempters were most likely to use soft methods such as sleeping pills and other drugs. When attempters did use a hard method, it was apt to

involve knife slashes and stabs, whereas few real suicides were attained by the knife. More than a third of the attempters notified someone after taking drugs or slashing themselves, so apparently they did not really want to die.

Can a suicidal predictor pattern be established from an individual's life history or from other scores? The answer is unquestionably yes for some populations. The small number of suicides that have occurred in the famous Terman gifted-child sample in America, for instance, showed some rather consistent behavioral precursors of their eventual self-destruction. The suicide-prevention agencies often point to the predictive importance of stressful life events, of failures in meeting expectations, of personality characteristics, and of definite plans for a suicide attempt. Flach's study of soldier attempters suggested that there is indeed cumulative stress from such problems as hospitalization, failure at work and at home, conflicts with the law, difficulties with alcohol, and adjustment to military discipline and military companions. Nearly half of the suicide-attempters reported conflicts between marriage partners or separation from partners, 37% had substantial debts or financial problems, about 20% had been punished by a military or civil court, and so forth. It was not, moreover, any one of these problems that brought about the attempt, but usually two or more that impinged on the person just before the crisis.

The suicide attempt figures are about one-third higher for the first 3 months of service than they are for the entire period; this probably indicates that for some individuals the shift to military life and military restrictions is extraordinarily demanding. Flach's questionnaire data confirm this quite clearly. Of the attempters, fully 47% said that they regarded the West German Armed Forces as detrimental or superfluous (only 21% of the non-attempter controls reported this attitude) and 82% said they would prefer some form of civilian service to military duty if they could make a choice (the comparison figure was 44% in the matched controls). Attempters were more than three times as likely as the controls to have received disciplinary punishment and more than seven times as likely to have been AWOL.

Adjustment to military life was not the only factor; in post-attempt interviews only 18% of the soldiers attributed their crisis entirely to the military situation, whereas 38% said it was due entirely to life events outside the military and 43% said that the key forces were both within and outside the military. Flach's results are corroborated by a separate 1979 study by the commissioner of the German Armed Forces. In that investigation, unit leaders reported that at least half of the attempting soldiers simply could not cope with their military call-up.

Alcohol is often a key factor in civilian suicide; hence the cliché in some hot-line phone centers that the most likely suicide victim is "a middle-aged professional man in his fifties, who has had occupational, health, and personal

difficulties lately, has been drinking heavily, and knows how and when and where he wants to do it." Nearly half of the German soldier attempters admitted that they had difficulties in connection with alcohol, and fully 42% said alcohol had a direct influence on their actual attempt. Flach sees alcohol as an accelerator or multiplier of the cumulative impact of other events, because alcohol brings its own circular process of transitory euphoria followed by socially offensive behavior, rejection, depression, and hopelessness. In this context, it should be remembered that the military environment facilitates consumption of alcohol by such means as near-universal drinking by model persons, provision of cheap beverages and bar services, and so forth.

Personality questionnaire scores in the attempting soldiers showed the expected patterns: more loneliness, more feelings of inferiority, more exhaustion, irritability, and fear. On the Rotter-derived external-vs-internal control measure, the attempters tended to see themselves as more externally controlled. In the usual view, this attribution means that they see their lives not as dependent on their own behavior, but rather as determined by luck, fate, or unknown persons and forces. This again leads to a circular pattern of resignation and hopelessness.

Recent work by Irwin Sarason (Univ. of Washington) and by S.J. Rachman (Maudesley Hospital, UK) has shown the importance of "life support" in predicting delinquent and inadequate behavior. Persons who are more isolated socially and have only weak social support systems are more likely to go AWOL or to have alcohol or drug problems. Members of the German soldier attempter sample give responses that accord with a social support view; they describe themselves as socially more reserved and less able to make friends than soldiers in the control group.

Flach's results lead to a checklist or predictor profile of seven or eight factors that can be expected to identify soldiers with high-risk suicide potential. The German forces are taking explicit steps to train leaders at the platoon and company level to watch for people who may be at high risk; basic training managers are advised to give special attention to those who have great difficulty adjusting to military life early in their training period. New and explicit attention to the social support phases of barracks life is also emphasized.

Much speculation has been directed to the wide differences observed in suicide rates among countries, among areas of the same country, and among occupational groups. Rates for US and UK military units are quite low. The official Austrian civilian suicide rate is 10 times that reported for Greece; San Francisco's rate (27.5/10<sup>5</sup>) is three times that for Washington, DC; Ireland's rate is less than a third that in Sweden or West Germany. Occupationally, psychiatrists are more at risk than any other medical specialists, chemical engineers almost

never kill themselves, and so on. Many more or less plausible explanations can be formulated for these patterns. Some are psychoanalytically based. As an example, the Irish wake includes participation by everyone in the family including children; working through these wake experiences may help the Irish youngster to come to terms with loss and death early in life. Another explanation, based on modeling, goes like this: in countries such as Greece and Turkey a stoic acceptance of hardship and difficulties is part of the prevailing philosophy of life, and suicide is not considered to be acceptable and honorable behavior. Some popular explanations are palpably absurd: hundreds of people have died by jumping from San Francisco's Golden Gate Bridge, so one often hears in that city that the jumpers "have come as far as they can and there's nowhere left to go." Actually, only about 12% of San Francisco's listed suicides jump from the bridge. A few Golden Gate jumpers have survived; at least one regularly tours colleges recommending that students should not attempt suicide.

More prosaic explanatory hypotheses can be found, and they have the virtue of being verifiable. To illustrate: perhaps there are so many San Francisco suicides because the city is small, densely packed, and has relatively high proportions of elderly and disturbed people living in it. Maybe Greece's rate is so low because the reporting system there is less complete and accurate. Physiological predictors may turn out to be the best predictors of all. Swedish studies suggest that suicidal people may have less serotonin in their cerebral spinal fluid (ESN 35-7:249 [1981]); norepinephrine in the brain can also influence moods and depressive states.

Perhaps more significant than the array of explanations offered is the development of some empirical predictors of suicidal tendencies. As careful work like Flach's accumulates, military leaders and clinicians can do a better job of singling out the most susceptible individuals. Awareness of the need for social support in many new recruits may also lead to general consideration of social isolation in military groups.

*Nicholas A. Bond, Jr.*

ONR London

## **BIOLOGICAL SCIENCES**

### **BIOELECTROCHEMISTRY AT ERICE, SICILY**

The "Ettore Majorana" Center for Scientific Culture in Erice, Sicily, (director, Prof. A. Zichichi) was established in 1963 "...to create in Europe a cultural forum of high scientific standard..." by bringing scientists into contact with more experienced colleagues for discussion

and further training. This aim has been carried out through the organization of schools of which there are now about 70, both national and international. The scope of the subjects is unusually broad, covering such diverse areas as astronomy, electron microscopy, atmospheric physics, genetics, geology, medical science, marine biology, philosophy of science, logic, scientific methodology, and material science. The first school founded was in physics, and the emphasis of the center is clearly on physics and its various subdivisions and interdisciplinary combinations. (Ettore Majorana, for whom the center is named, was a physicist at the University of Palermo.) The International School of Biophysics, under the directorship of Prof. A. Borsellino, was the sponsor of the course on bioelectrochemistry, its eleventh and the first on the subject. The organizers were G. Milazzo (Rome) and M. Blank (New York), and the course ran from November 29 to December 5, 1981.

Bioelectrochemistry is a broadly defined interdisciplinary area that deals with the application of the principles and techniques of electrochemistry to problems in biology. The course was limited, however, to biological redox reactions and their energetics. The lecturers and their subjects were G. Milazzo (Univ. of Rome), introduction; R. Buve (Paris), general energetic criteria; H. Metzner (Univ. of Tübingen), photobiological redox reactions; B.A. Melandri (Univ. of Bologna), energetics of enzymatic redox reaction; H. Berg (Jena), kinetics of biological redox reactions; H.W. Nurnberg (Central Institute of Analytical Chemistry, Nuclear Research Center, Jülich, FRG), advanced voltammetric methods; M. Blank (Columbia Univ., New York), membrane potentials; D.F. Wilson (Univ. of Pennsylvania, Philadelphia), respiratory chain; I.R. Rao (Erlangen), biomedical application; and G. Milazzo, summary.

There was a strong international flavor to the meeting, with 11 nations represented among the 37 participants. The largest groups were from Italy (14), as expected, and West Germany (9), but the US and Israel were represented and other European nations included East Germany and Poland. There was also a decided interdisciplinary atmosphere to the lectures and the discussions, as the participants were divided more or less equally between departments of physical chemistry and various biological disciplines.

The 30 hours of lectures, with the exception of the introduction and summary, were scheduled in blocks of 2 to 5 hours. The 1-hour lectures were interspersed with short breaks to help ease the intense pace. Although the styles of the lecturers were different, all tended to follow the same pattern in the development of their subject: an historical introduction followed by the presentation of the general principles, techniques, and basic observations. (The mix of theoretical and practical aspects was always tilted toward the practical.)

The last hour was usually devoted to a discussion of an advanced topic, occasionally controversial, that brought the students right up to the frontier of the area. The formal coverage was quite complete for the relatively short time allotted, and the small size of the group helped to stimulate discussions to round out the subject during breaks, meals, and in the evenings.

The course was introduced by Milazzo with a short history covering the early controversy between Galvani and Volta about animal electricity, the pioneering studies of J.W. Ritter a generation later, and many of the more familiar contributions like those of D. Keilin on redox chains and A. Szent-Gyorgi on electronic processes in biological systems. Milazzo stressed the interdisciplinary aspects of problems in bioelectrochemistry and the need for a true blending of information from various fields of biology and electrochemistry in order to make progress. He mentioned problems in biological structure, selective permeability, electrical potentials, transport, excitation, photosynthesis, and growth and repair mechanisms. Although the roots of bioelectrochemistry go back over 200 years, the renewal of formal activities in the subject started in 1971 with a meeting organized by Milazzo in Rome. Since that time, six international meetings have been held; a journal, now in its eighth year, was established; a review volume series was begun, of which four volumes have been completed; a Gordon Research Conference on the subject was held in the US; and now the first "school" at Erice has been founded.

Buvet opened his lectures by classifying reactions according to whether they involved simple electron exchanges, electron and proton exchanges, or a modification of covalent topology. (Because of the very different speeds with which electrons and nuclei move, the last criterion bars reactions requiring simultaneous movements.) He also discussed a method for balancing redox equations involving the oxidation degree and the oxidation number of carbon atoms. The next topic considered was energy balance of redox reactions, and an interesting problem of terminology surfaced. In English-speaking countries the Gibbs free energy ( $G$ ) has the same symbol as in France and Germany, but it is called the free enthalpy, in line with IUPAC convention. This language difference led to some odd questions and answers until the proper translation was made. Buvet then discussed redox energy storage by photosynthesis and some aspects of oxidative phosphorylation. He presented his idea of hydrogen peroxide as an intermediate at the third phosphorylation site in mitochondria, and this led to lively discussion that continued through the week.

Metzner built upon the general introduction and considered the special biological redox systems that involve interactions with light. Starting with a consideration of the ways in which molecules can be excited by light, he outlined the general properties and went on to

describe the behavior of chlorophylls and carotenoids and the role of the specialized thylakoid membrane. The rest of the presentation was devoted to photosynthesis, both in bacteria and in higher plants, and to ATP formation. In attempts to unravel the mechanism, many lines of evidence were presented including the use of isotope effects (to trace the path of individual atomic species) and a bacterial mutant without carbonic anhydrase that could photosynthesize (to examine the role of bicarbonate ions in the process). Metzner ended the series with a discussion about the possibilities of using natural systems (e.g., hydrogenases to form hydrogen gas, parts of the photosynthetic system to fix  $\text{CO}_2$ ) and applying electrochemical methods that work under laboratory conditions.

Melandri presented a detailed discussion of enzymatic reactions, emphasizing the different prosthetic groups (spectral and redox properties) and the role of intermediates (bound or freely diffusible) in the redox mechanisms. When enzymes are grouped in a complex or a compartment, the problem of diffusion is minimized and reactions are greatly facilitated. The need to transfer substrates between compartments led to a discussion of the role of membrane potentials on these processes. The final subject in this series was the coupling of redox reactions to other processes such as oxidative and photosynthetic phosphorylation.

Berg lectured on photoredox reactions from the kinetic point of view of. Analyzing redox reactions in terms of the main reaction as well as pre-, post-, and parallel reactions, he developed equations that describe the rate constants and the variation of substrate concentration at an electrode surface. He also discussed photoreactions in solutions that involve proteins or DNA, e.g., photodynamic action with porphyrine as sensitizers and the breaking of single- and double-stranded DNA. In the final hour, Berg dealt with electric field effects on biological systems, covering such topics as the synthesis of ATP by electrical pulses, the fusion of membranes, and his own recent work on the fusion of cells in a zygote using fine metallic microelectrodes. Light and electric field effects are complementary, as can be seen from the ATP synthesis experiments, and there are many possible uses for the two effects in medical application.

There was a strong shift of emphasis toward techniques in the next series of lectures, given by Nurnberg. Voltammetric methods were first employed by Heyrovsky using the dropping mercury electrode, but now there are many different techniques available in terms of electrodes (including graphite and glassy carbon), potential ranges, and scan rates (e.g., ramp voltage, single sweep, AC methods). Nurnberg described the methods and the advantages of each. It is possible to analyze organic substances in the concentration range  $10^{-3}$  to  $10^{-7}$  M and heavy metals from

$10^{-3}$  to  $10^{-12}$  M. Because of their sensitivity, voltammetric detectors have advantages over UV in new High Pressure Liquid Chromatography (HPLC) methods for measuring amino or phenolic compounds and have proved useful in detecting trace estrogens in animals that have been given such hormones to increase meat production. The last topics covered included the use of AC methods to study the interfacial behavior of nucleotides (e.g., molecular orientation) and the recent surface-enhanced Raman spectroscopy to corroborate voltammetric measurements.

Blank's lectures were on natural membranes and membrane potentials as a basis for understanding some redox processes. He started with a review of what is known about the structure and composition of membranes, using the red cell as a prototype, and considered what kind of physical phase a membrane may represent—is it more like a surface film or a bulk phase? The next subject was a description of the physical processes at surfaces (e.g., electrical double layer formation, special effects in diffusion processes, concentration changes during current flow, and the special aspects of membrane reactions). The two subjects were brought together in a discussion of excitation in natural membranes, and Blank showed that by invoking some of the physical processes that occur at surfaces it is possible to demonstrate the unusual inward sodium ion flux that is characteristic of excitable membranes.

Building upon the ideas of membrane structure, Wilson returned to the theme of biological redox reactions and discussed the respiratory chain in mitochondria. He described the four different complexes in the electron transport chain of the inner mitochondrial membrane and some of the spectral and potentiometric properties of the complexes. Of special interest was the problem of oxygen reduction and the various components of the complex containing cytochrome oxidase. The final subject considered was the coupling of redox reactions to ATP synthesis, and he presented data to show that the respiration rate is proportional to the ATP potential (i.e., the logarithm of the equilibrium constant relating ATP, ADP, and P) rather than just the ATP:ADP ratio. Some of his recent experiments on the arterial-venous oxygen difference in the heart show that the regulation of blood flow is apparently similarly governed.

The final subject, covered by Rao, was electrochemical methodologies in biomedical applications. Rao focused on energy sources (i.e., biocompatible batteries), the problems of sensor electrodes, and some special applications (e.g., cardiac pacing). After developing the principles of battery design, Rao discussed biogalvanic cells (where the body plays a role, e.g., by supplying oxygen) and biofuel cells (where biological fuel such as glucose is used). Although these cells offer interesting possibilities, the  $\text{Li-I}_2$  cell appears to have great

advantages at the moment in terms of power and longevity ( $\sim 10$  years). The next discussion centered on the great increase in the use of specific electrodes and the current work on incorporating enzymes as in the search for a glucose-sensing electrode. The chief medical application is in cardiac pacing, but other areas are developing. The last subject covered one such area, detoxification (e.g., removal of urea in end stage renal failure) by electrochemical reactions.

Judging from the number and quality of the slides and transparencies used by the lecturers, a considerable effort had gone into the preparation of the talks. The students were also quite well prepared. Although most of them were at relatively early stages of their research careers, there were several well-established investigators, and the questions and discussions were on a high level. The school also provided a means of exchanging some of the latest information from a number of active laboratories during the informal sessions. One line of research that seemed to interest everyone was the work of Prof. Joan Smith-Sonneborn (Univ. of Wyoming) on paramecia. The particular species she is studying, *Paramecium aurelia*, normally lives for up to 200 cell divisions. The species can also take part in a form of sexual reproduction whereby two individuals exchange nuclear material. Apparently sexual reproduction can reset the clock and extend the lifetime of a cell line. To be effective, however, the sexual reproduction should come before 100 divisions (i.e., before the accumulation of irreversible nuclear damage), and as an optimum it should occur every 20 divisions. Smith-Sonneborn has also studied the behavior of these cells when stimulated by ultraviolet radiation followed by photoreactivation, and by low amplitude electromagnetic fields (frequency  $\sim 15$  Hz); she has found that the stimulation results in an extension of the cells' ability to divide.

The proceedings of the course will be published by Plenum Press, probably by summer 1982. The next course in bioelectrochemistry is being planned for November 1984 on the subject of electrochemistry of biological membranes. In the meantime, there will be a number of related meetings on bioelectrochemistry that one can attend, including a Gordon Research Conference in summer 1982.

*Martin Blank*

Columbia University, New York

#### BIOPHYSICS OF CELL SURFACE - AN INTERNATIONAL MEETING

The Third International Symposium "Biophysics of Cell Surface" took place on November 23 to 28, 1981 in Arendsee, East Germany (GDR). Two-thirds of the 158 scientists

registered for the meeting were from the GDR, but the visiting scientists from 16 countries provided an international atmosphere. There was a larger number of participants from the east than the west, the largest eastern European groups being from the USSR (8), Bulgaria (8), Poland (6), and Hungary (6), while the western nations included the UK (6), France (4), West Germany (3), and the US (3).

The meeting, as well as two previous ones in 1976 and 1978, was sponsored by UNESCO to promote scientific cooperation between nations. (In this connection, there are plans for additional small meetings on other aspects of biophysics as part of the same program. At the end of May there will be a meeting in Baltimore emphasizing modern instrumentation, and in September there will be one in Bucharest on water and ions.) The Humboldt University Department of Biology (East Berlin), and the Society for Physical and Mathematical Biology of the GDR cosponsored the meeting and were largely responsible for the well-coordinated arrangements.

The program consisted of 29 lectures and some 80 posters grouped according to three main topics: the control of membrane functions by electric and ionic events; active and passive changes of mechanical membrane properties, surface dynamics and their molecular basis; and cell and membrane contact, recognition, and fusion. Abstracts of the lectures and posters will be published in the journal *Studia Biophysica* in a relatively short time, as camera-ready abstracts were handed in at the meeting. In some cases, longer manuscripts were submitted and they will appear in the same issue in microfiche form.

The three topics listed above are at the forefront of cell and membrane biophysics today, but the papers presented at the meeting conveyed a somewhat different impression than the biophysics we are accustomed to in the US. There were great differences in emphasis and approach. Two months earlier, in Virginia, the author took part in the Third Biophysical Discussion on "Protein-Lipid Interactions in Membranes," a topic closely related to the subject of the Arendsee meeting, and a comparison of the two expressions of biophysics points up the differences. In the US, the emphasis was on new techniques (e.g., NMR, ESR, fluorescence) and on interpreting the observed spectra in terms of molecular properties, i.e., molecular biophysics. At Arendsee, the emphasis was on the classic problems of membrane biophysics (e.g., transport, origin of membrane potentials), and effort was devoted to classical theoretical work and to simple experiments (e.g., measurements of transport or potential). It is obvious that the availability of the new machines in the US has shifted the focus of the field away from the classic unsolved problems. By the same token, the limitations on support in many eastern European countries have forced many scientists to do theoretical work (e.g., on the applicability of

electrical double layer theory to membrane systems). (It is interesting to note that Verwey and Overbeek developed their theory of colloid stability from electrical double layer theory in The Netherlands during World War II, when they could get no support for research.) The experimental work is also generally on simpler systems (e.g., the red blood cell), probably for the same reasons. But the mix of papers, seen mainly among the posters, gave evidence of extensive activity in the field and some rather resourceful approaches to problems.

The emphasis on theoretical aspects of cell biophysics was highlighted by the opening lectures. The first talk, by B. Pullmann (Institut De Biologie Physico-Chimique, Paris) was on the computation of surface potentials in phospholipid layers *in vacuo*. Using molecular coordinates from crystals of dilauroyl phosphatides, he was able to show regions of positive and negative potential along the surface of layers containing either ethanolamine or choline polar groups. These computations were quite sensitive to the positions of the charged species (e.g., P or N atoms), which would change if water were introduced into the system. In his earlier work on nucleic acids, Pullmann started with the molecules *in vacuo* and then added ions and water to arrive at physically reasonable values. A. Pullmann (Institut de Biologie Physico-Chimique, Paris), the other half of the team, then discussed the energetics of cation-ionophore binding. Here too, the computations of energies of interaction were extremely sensitive to slight displacements of the ion out of the plane of the ionophore, but it was possible to show qualitative differences between Na and K ions in some cases.

The next group of papers treated several different membrane problems. A. Kotyk (Prague) discussed the membrane potential and active transport in yeast, particularly in connection with the transport of protons. He emphasized the idea that the proton motive force is probably not between bulk phases but rather across the transport system in the membrane. Barsukov (Moscow) then presented data on phospholipid dynamics in liver microsomes, where there appear to be great differences in the phospholipid flip-flop rate between hepatoma ( $t_1/2 > 3$  hrs) and normal liver ( $t_1/2 < 2$  mins) cells. M.J. Allen (Univ. of Nottingham, UK) gave the last paper of the morning on some electrical effects in leaf membrane systems. The interplay between electrical and pressure effects can lead to some unusual increases in current that may be due to conductance along the surface of the leaf.

The three afternoon lectures dealt with surface processes relevant to membranes. J. Koryta (Prague) discussed his recent work on ion transport across interfaces between two immiscible electrolyte solutions, a kind of polarography not involving mercury. When adsorbed phospholipid monolayers are present at the interface, the system is a model for cell membrane transport processes. M. Blank (Columbia

Univ., New York) presented a model for ion transport across membranes that took into account surface processes that occur within the electrical double layer region. The set of equations that describes surface processes can show the characteristic behavior of an excitable membrane, i.e., the influx of sodium ions in response to a depolarization, when there is a non-specific increase in the membrane permeability to cations. H. Sonntag (East Berlin, GDR) spoke about adhesion in the presence of adsorbed macromolecules, describing the various conformations of the polymer at an interface and how that affects the interactions between surfaces.

The following day there were talks by F. Bentrup (Tubingen Univ., FRG) on amino acid transport in plants, E. Mahler (Nancy) on cell electrophoresis using laser Doppler velocimetry, and R. Glaser on transport, membrane potential, and the shape of red blood cells. Glaser and his group at Humboldt University have done many different experiments on red blood cells and have suggested that the red cell shape (e.g., stomatocyte, echinocyte) is modulated by the membrane potential. M.P. Sheetz (Univ. of Connecticut, Farmington) gave an excellent summary of red cell membrane dynamics, and from his own work on photo bleaching stressed the importance of the spectrin network in controlling phospholipid and protein band 3 diffusion in the membrane. Dr. Gallez (Brussels) described progress in her theoretical model for the mechanical stability and rheological properties of natural membranes. It is interesting that the introduction of electrical terms destabilizes the system, suggesting that there may be a relation with membrane shape changes. The last paper of the morning by V.S. Vaidhyanathan (State Univ. of New York, Buffalo) on the dielectric profile and ion distribution near a cell surface described a theoretical approach to the Stern correction without assuming a binding isotherm. In the afternoon, I. Abidor (Moscow) talked about the electrochemical properties of bimolecular membranes, S. Svetina (Univ. of Ljubljana, Yugoslavia) discussed shape changes in red cells as dependent upon changes in membrane area following ion binding, and D. Platikanow (Sofia) reviewed the properties of thin films of proteins, formed as in the case of soap films.

The interactions of electric fields with cell membranes have been studied extensively because of the membrane breakdown and fusion that can result from such processes. Y. Chizmadjev (Moscow) described the results of his experiments with lipid bilayers and liposomes, H. Berg (Jena) introduced a new technique using metallic microelectrodes to cause the fusion of cells in a developing zygote, and U. Zimmermann (Institute of Chemistry, Nuclear Research Center, Jülich, FRG) reviewed his findings on high-frequency fusion of red cells into giant cells. To round out the morning program, I. Sugar (Budapest) presented a

theory of the effects of external fields on phospholipid bilayers in terms of changes in the order parameter, W.T. Coakley (Cardiff) lectured on the effects of temperature on the binding properties of red cell membranes, and N.M. Delgado (Mexico City) described the binding of heparin to human spermatozoan membranes.

The speakers on the final day included Dolowy (Poland) on an electrochemical model of the cell membrane, cell adhesion, and motility; M. Hill (Cambridge) on the changes that occur to specific ion pathways in liposomes prior to membrane fusion; and D. Hulser (Stuttgart) on the molecular basis of gap junction formation. In the last session, D. Gingell (London) discussed cell spreading on defined substrates, W. Korohoda (Krakow) related cell metabolism and cell contact reactions (e.g., motility), and S. Ohnishi described the interactions of influenza virus with cells and phospholipid model membranes. As the uptake of the virus is by fusion of the lipid envelope with cells, factors that inhibit the process (e.g., alkaline environment) may be useful for combating the effects of the virus.

Some of the many posters were of special interest. Those of the Glaser group, mentioned earlier, described various aspects of their approach to red cell membrane properties. I. Bernhardt studied passive K efflux and active Na efflux as functions of membrane electric field (i.e., the difference between the inside and outside surface potentials). R. Heinrich and M. Gaestel described a mathematical model of the potential profile across the red cell membrane using the ideas of electrical double layer theory. They also had a poster on potential-related shape changes. Others in the group (A. Herrmann, K. Arnold, G. Lassmann) described spin label studies on red cell membranes.

Other groups from the Humboldt University presented posters on polarographic studies in cell suspensions (A. Voigt, H. Wolf), on physicochemical compartments in excitable cells and their effects on the transmembrane potential (R. Dehmlow), the effects of these compartments on potential changes during excitation (K.P. Leiterer), the electrophoretic mobility of normal and inside-out vesicles made from red cell membranes (E. Donath), and the extension of the electrical double layer approach to include the red cell outer membrane surface charge in the glycocalyx (D. Lerche).

Posters from other laboratories included those by M. Venslauskas (Kaunas, Lithuania) on the estimation of the energy of interaction between surfaces of red blood cells and by S. Stoylow (Sofia) on the dynamics of electric charge flow in purple membrane of halobacteria.

The meeting was well organized and the discussions, both formal and informal, as well as the social interactions testified to the liveliness of the proceedings. The organizers should be congratulated for their efforts,



especially as the facilities were not designed for scientific assemblies.

*Martin Blank*

Columbia University, New York

**CARDIAC REHABILITATION—A WORLD  
CONGRESS: PART II**

This is the second part of an article on the Second World Congress on Cardiac Rehabilitation. The first appeared in ESN 36-1:5 (1982).

The psychologic and psychiatric aspects of coronary artery disease, myocardial infarction, and coronary artery bypass graft (CABG) came in for considerable discussion at the congress. In fact, the results of a long-range randomized Italian study on physical training (presented by S. Marra) and a similar study from the Mayo Clinic (presented by G.T. Gan) showed the most important benefits to be psychological. The Mayo Clinic study searched for, and found, increased marital happiness among the participants in the rehabilitation program and less consumption of alcohol than in the control group. Again, the studies were criticized for dealing with relatively small groups of patients and for omitting observations of the educational level of the patients.

The value of therapeutic psychiatric consultation and psychologic evaluation in connection with CABG seems universally recognized. Objective indices of cardiac function and the subjective states of the patients are frequently at odds, resulting in difficulty in assessing the effectiveness of postoperative rehabilitation. Familial and individual psychologic factors, as well as social and professional pressures, may provide clues to these discrepancies. Investigators are searching for prognostic indicators related to psychologic adaptation. J.P.M. Diederiks (The Netherlands) presented a plot of coping strategies, compartmentalization, vacillation, and generalization, showing how the tendencies towards or away from extraversion and neuroticism develop. A large group of patients was classified, plotted, and followed for 24 months. With an excess of psychologic and statistical jargon, the study seemed to show that vacillation is associated with an unfavorable outcome and that compartmentalization is a favorable and stabilizing psychologic mechanism. P. Lorente (Paris) showed that good results are correlated with the absence of neurosis and subjective symptoms and the presence of a favorable partner reaction.

The pharmacology of coronary artery disease is an area of intensive investigation. The classes of drugs of greatest contemporary interest are the calcium antagonists, the beta-adrenergic blockers and the anti-platelet drugs. Also discussed were the classical anticoagulants,

the vasodilator nitrates, and enzymes for reducing infarct size. Calcium antagonists (e.g., nifedipine, diltiazem) slow the transfer of calcium across the membrane of the cardiac muscle cell, making it less available for its essential role in normal excitation and electrical conduction. This action in peripheral vascular smooth muscle results in vasodilatation. Beta-blockers (e.g., propranolol, metoprolol) prevent activation of sympathetic receptors in the heart and central nervous system; thus by a different mechanism they slow the heart and reduce its force of contraction. Both groups of agents slow the heart, reduce blood pressure, relieve anginal pain, and prevent arrhythmias.

The calcium antagonists and beta-blockers have been shown to have favorable effects on pain and arrhythmias in patients with coronary artery disease, and new agents are under development in each class. Of course, side effects and adverse reactions are not uncommon, as there are effects on other body systems as well. Comparisons of the agents were not conclusive at the congress, but it was agreed that both may not be used simultaneously because both lower the blood pressure. R. Rost (Cologne) reviewed the differences in the agents in hemodynamic responses, oxygen uptake, ventilation, and several metabolic parameters. J. Fitzsimons (Univ. of Cambridge, UK) demonstrated that the slow heart rate (bradycardia produced by beta-blockers) does not inconvenience patients and should not be a reason for discontinuing these agents, even in the elderly.

D.G. Julian (Univ. of Newcastle, UK) reviewed the role of drugs in rehabilitation. They increase exercise tolerance and improve prognosis through prevention of thrombosis, reduction of the incidence of serious arrhythmias, and possibly through reduction in size of infarcts (enzymes). J.P. Broustet (Bordeaux-Pessac, France) compared the calcium antagonists diltiazem and nifedipine in a group of patients with angina pectoris due to effort and found that diltiazem increased exercise capacity to a greater extent than nifedipine plus nitroglycerin, and was 70% more effective than nifedipine alone. A single dose was still effective the following morning. At comparable heart rates, diltiazem patients reached a higher work load before the onset of angina than did patients on beta-adrenergic blocking drugs.

P. Sleight (Oxford Univ., UK) and his group reported on the value of an intravenous beta-blocker, atenolol, given very soon after the occurrence of myocardial infarction. He reviewed studies from Norway, Sweden, and the US on the effectiveness of these agents and expressed the belief that many lives could be saved by this approach. He regards the acute effects of the treatment as reduction of infarct size and prevention of arrhythmias, the chronic effects as reduction of arrhythmias and, possibly, prevention of reinfarction. Electrocardiographic mapping and enzyme levels were used to demonstrate reduction in the size of the



infarct, but Sleight emphasized that "you have to get in early" with this method of treatment. Even with late entry, as in the American propranolol trial in which the drug was started 5 days post infarction, the mortality was 26% less than in the control group. Analyzing the mechanism of action of the beta-blockers, M. Thomas (UK) provided data on reduction of oxygen consumption by the myocardium in treated patients. Thus, when the coronary circulation is compromised, there is relatively less damage.

Van Aken (The Netherlands) discussed anticoagulants and platelet-active agents that prevent thromboembolic phenomena in the deep veins, left ventricular thrombosis and systemic emboli, and thrombosis in the coronary vessels themselves. At autopsy, 20% of myocardial infarct victims have a thrombus in the left ventricle, and this incidence rises to 50% when the infarct is transmural, that is, extending across the full thickness of the ventricular wall. The diagnosis can be made in life by two-dimensional echocardiography. Oral anticoagulants and low-dose heparin as usually employed are ineffective in preventing these complications. Prophylactic drug therapy must follow the infarction immediately and full-dose intravenous heparin may be necessary. Many studies of the importance of platelet aggregation and vascular spasm in the pathogenesis of myocardial infarction are now in progress. Aspirin and other inhibitors of prostaglandin and thromboxane synthesis, as well as the platelet-active agents dipyridamine and sulfinpyrazone, may have important roles. Many studies of the effectiveness of these drugs in prophylaxis and in the prevention of reinfarction need to be reanalyzed.

A major part of the congress was devoted to the predictive value of exercise testing, with a variety of technical modifications. One session, chaired by S. Stern (Israel) and C. Wilhelmsson (Sweden), dealt with continuous 24-hour electrocardiographic monitoring in coronary heart disease patients for evaluation of symptoms such as dizziness and fainting, and during exercise therapy. In another session under the leadership of E.A. Amsterdam (Univ. of California, Davis) and V.F. Froehlicher (San Diego, CA), other non-invasive techniques such as echocardiography, systolic time-interval measurement, telemetry, and radionuclide cineangiography were discussed.

Symptom-limited exercise testing is generally accepted as an integral part of any cardiac rehabilitation program. Panelists were agreed upon the many factors that justified such exercise: the discovery of latent disease, the differential diagnosis of chest pain, the prediction of exercise tolerance and coronary risk, and the motivation of both physician and patient. M. Niederberger (Vienna) emphasized that patients with normal exercise tolerance are not candidates for CABG, even if they have demonstrably operable lesions in the coronary arteries. If exercise capacity exceeds 4 METS

(units based on metabolic equivalents of different types of exercise) the mortality is the same as in an unselected population. Extensive discussion concerned false positive and negative tests.

J.S. Borer (New York) added a paper on the additional value of radionuclide cineangiography in predicting patients at high risk. The movies of the beating heart demonstrate the extent of regional abnormalities of left and right ventricular function and permit estimation of ejection fraction at rest and in exercise. Patients can thus be stratified according to risk. In a summary statement on this subject, R.A. Bruch (Univ. of Washington) described his experience with the "Seattle Heart Watch," a 10-year follow-up of coronary patients. Clear risk factors are rare, age 55 in men being one. The best predictor of coronary heart disease events is the interaction of common risk factors and exercise test factors. The end point of a program of evaluation and rehabilitation is survival without coronary heart disease events—a reduced event rate.

Several cautionary statements were made concerning the value of vigorous physical conditioning in coronary patients. As M.L. Pollack (Univ. of Wisconsin, Milwaukee) pointed out, the evidence for the value of physical activity is more solid for primary than for secondary prevention. In general, the more physical activity, the fewer fatal heart attacks, but minimal thresholds for fitness must be exceeded. Pollack recommends starting the exercise program early after a heart attack or after surgery, with arm work 2 to 3 days postoperatively. Exercise prescriptions must include specifics of frequency, intensity, duration, mode, initial health status, initial level of fitness, and minimal threshold for fitness. A perceived exertion scale correlates well with heart rate, ventilation, and biochemical tests of metabolism. Exercise should be conducted 3 to 5 days per week, continuously for 15 to 60 minutes, to increase heart rate to 60 to 90% of maximum and oxygen uptake to 50 to 80% of maximum. Recommended modes are running, jogging, walking, bicycling, swimming, and endurance sports. Maximum heart rate is determined by stress testing to limits imposed by symptoms.

Several exercise programs were described, but randomized studies on outcome are rarely conclusive. Hellerstein noted that the alleged immunity of marathon runners to coronary disease has been disproved and urged realistic testing and training related to the demands of the patient's work tasks, specific muscle groups, and his environment. Still, other investigators described the process of making marathon runners out of coronary patients. Wenger emphasized that there is no fixed dose of exercise. Training is determined by a safe, effective workload that challenges the body's oxygen transport system, keeps down the risk

of myocardial ischemia and orthopedic problems and is periodically assessed and revised.

There remains considerable empiricism in this chemical field, fortunately tempered by common sense. As R. Rost pointed out, there are several known paths of useful intervention after myocardial infarction and a negative picture need not be accepted. He made the following recommendations (usually included under the rubric of secondary prevention—halting, braking, or slowing the progress of coronary heart disease in those who have survived a coronary attack):

Diet and weight control. Normally this refers to reduced calories and reduced animal products. The scientific basis for this recommendation is poor. The factors are important in primary prevention but have no effect on the reinfarction rate. Still, there is no harm in recommending dietary changes.

Anti-smoking programs. Several studies have demonstrated the value of cessation of smoking.

Physical activity. The ability to increase performance capacity and the psychological benefits are uncontested.

Psychosocial stress reduction. Always a controversial area inasmuch as one man's stress is not another's, but there is clear-cut evidence for the importance of educational and economic levels in both primary and secondary prevention.

Medical treatment. Improvement in cardiac performance and limitation of the size of infarcts are attainable goals.

Control of arrhythmias. Because arrhythmias cause sudden death, it is unreasonable to withhold the medications that control them.

Control of hypertension. The recent US Hypertension Detection and Follow-Up Program has demonstrated the importance of this factor in primary prevention. Its role in secondary prevention is important but still controversial.

Control of metabolic disorders. While careful management of diabetes and the treatment of hyperlipidemia seem essential, there is still no clear evidence of value.

Anitcoagulant treatment. This presents dangers, and there is no clear evidence of its value in secondary prevention.

Beta-blockers and other drugs. Proof is emerging of their value in preventing arrhythmias and reinfarction as well as their oxygen conserving effects.

Coronary surgery and aneurysmectomy. CABG has gained scientific support. Aneurysmectomy, the removal of bulging, diseased, nonfunctioning myocardium, is under extensive study. Papers presented at the congress provided not statistically valid conclusions.

Kellerman came down hard on the long-term randomized trials on the national and international scale that formed the basis for much of the discussion at the congress. He

cited the problems of selection of comparable patients, dropouts, changing regimens, and varying endpoints. He suggested that physicians and investigators should pay more attention to the quality of survival than to survival itself. He was supported by H. Denolin (Free Univ. of Brussels, Belgium) who noted that several apparently similar studies had provided opposite results. Denolin suggested that optimists would be content to use the results of short-term unrandomized studies in managing patients, but pessimists would be weighted down by the fact that they would never know the true effects of physical training and other interventions in coronary artery disease.

The Third World Congress is scheduled to be held in Venezuela in 4 years. At this point, it is difficult to predict that there will be significant advances other than in methodologic and surgical technology.

*John C. Rose*

Georgetown University

## COMPUTER SCIENCES

### COMPUTER ARCHITECTURE RESEARCH AT NEWCASTLE UPON TYNE (UK)

The Computer Architecture Group of the Computing Laboratory at the University of Newcastle upon Tyne has been investigating the design of decentralized and parallel architectures under the sponsorship of the Science and Engineering Research Council's (SERC) distributing computing system program reported previously (ESN 35-8:[1981]). The investigation is aimed at providing alternatives to the conventional von Neumann architecture. The research specifically involves designing a single chip building block as a computing element that can be plugged into another computing element to form a parallel computer. Each computing element will contain the necessary memory, processing, and communication capabilities to permit such connection with other computing elements to form a larger computer and to cooperate in the concurrent software execution. The group is also attempting to identify a kernel model of computation that represents a synthesis of the concepts of data flow, control flow, and reduction models of computation that can be supported by the single-chip building-block architecture.

#### Computation Models

It was felt in Newcastle that two mechanisms are common to all models of computation, a data mechanism by which an instruction passes data to other instructions and a control mechanism by which an instruction causes execution of other instructions. The data mechanisms are further classified as follows:

(1) literal, in which data are known to an instruction; (2) value, in which data are passed directly between instructions; (3) reference, in which data are passed via a shared memory cell. There are also three subclasses of control mechanisms: sequential, parallel, and recursive. Using this approach, various computer architectures can be classified as follows:

		DATA MECHANISM	
		BY VALUE (& LITERAL)	BY REFERENCE (& LITERAL)
CONTROL MECHANISM	SEQUENTIAL		VON NEUMANN CONTROL FLOW
	PARALLEL	DATA FLOW	PARALLEL CONTROL FLOW
	RECURSIVE	STRING REDUCTION	GRAPH REDUCTION

Two particular projects have been undertaken by the group for studying data-driven and demand-driven computer architectures. The first has involved the study of the actual program organizations and their suitability for general-purpose decentralized computer systems. In the second the group used software and hardware simulators to investigate data-flow, multi-thread control flow, reduction architectures, and combinations of more than one in a single computer.

#### Data-Control Flow Computer

A computer called JUMBO has been built to study the integration of data-flow and control-flow computation models described above. The software organization of JUMBO includes both data tokens and control tokens. Combinations of the tokens enable a particular instruction to be initiated. In this architecture, an instruction may obtain input operands by receiving a data token with a value or an address of a stored value or by means of embedded inputs (literal or address) stored in the instruction. When an instruction is enabled, the token inputs and embedded inputs are merged to produce a set of values and addresses. The addresses of inputs are then replaced by their corresponding values from memory. The instruction then becomes executable with a complete set of value arguments. An instruction consists of an operation code and up to eight arguments. Certain arguments are embedded and others are run-time data tokens. Each operation code uses arguments in specific positions for inputs and places results in other positions. Therefore, an instruction is composed of the following fields: an operation code; up to eight embedded arguments; a position field, comprising the positions of arguments present; an input mode, defining combinations of merged token and embedded arguments; an output mode, specifying combinations of arguments and results to produce the output of the instruction. There are three types of outputs: memory data, data

tokens, and control tokens. Each consists of a reference and a value. For memory data, the name gives the address; for tokens, it provides the address of destination instruction and control information of tokens matching with other tokens in the set, such as token counts. In JUMBO, up to four tokens may be grouped in a set; a data token may contain more than one operand.

The hardware of JUMBO is a packet communication type with token matching. It consists of three major units connected by first-in-first-out buffers: (1) the matching unit, which controls the enabling of instructions by matching sets of tokens that are released to the memory unit; (2) the memory unit, which provides storage for data and instruction, and, for token set packets, constructs executable instructions to be released to the processing unit; (3) the processing unit, which executes the instructions and distributes results. This arrangement is shown in Figure 1.

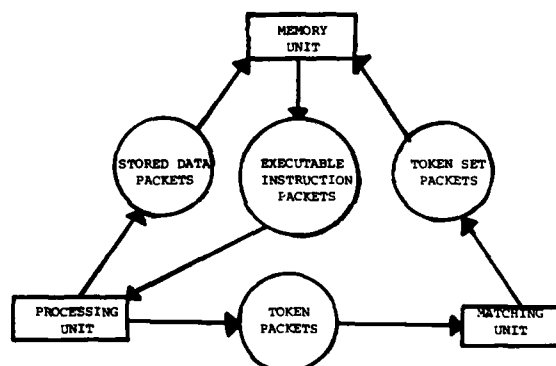


Figure 1

When a token set packet is released by the matching unit, it contains up to four input arguments supplied by data tokens. Using the destination instruction address in the packet, the memory takes a copy of the target instruction and merges the token arguments with those embedded arguments. The copy of the instruction then has a complete set of arguments. The input mode field, which is an 8x1-bit vector, is extracted. For each set bit, the corresponding argument is considered to be a memory address and is replaced by its corresponding value to give an executable instruction.

All three units in JUMBO are built from a Motorola M6800 microprocessor system. Memory is divided into 1 K-byte pages. Each process being executed in the computer has three pages, one for tokens in the matching unit and one each for code and data in the memory unit. Processes can be created and killed dynamically, and the token page can be reallocated to delete residual tokens.

### Reduction Machine

The objective of the university's reduction machine project is to investigate the use of parallelism in such architecture and also to explore the feasibility of basing these designs on a few replicated very-large-scale integration parts from the "Building Block" project. It resulted in the design and simulation of a parallel, string-reduction computer. It uses state-table-driven processors that allow the computer to be evaluated by means of different reduction language schemes.

The program organization of the particular reduction scheme under evaluation uses string manipulation. References may occur to a string and these are substituted by the corresponding definition at run-time. A parallel innermost computation rule is assumed. An expression in the program is delimited by brackets and consists of a function followed by a list of arguments (i.e., Function arg 1 arg 2 - - -). Here a function is a simple operator, but an argument could be a literal, a reference to a definition, or a bracketed expression to be reduced.

In addition to arithmetic, logic, and conditioned operators, there are LOAD, STORE, and APPLY operators used explicitly to access definitions. APPLY is used to bind arguments to a function.

Figure 2 depicts the machine architecture.

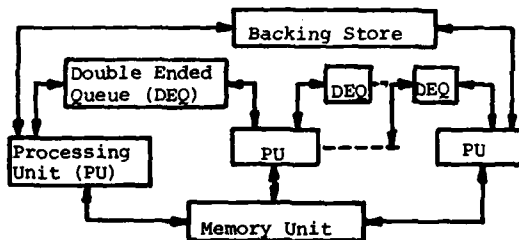


Figure 2

The architecture, an expression manipulation type, consists of three parts: a common memory for the definitions, a set of identical asynchronous processing units and a segment shift register for the expression being evaluated. This shift register comprises a number of double-ended queues for parts of expression being traversed and a backing store to hold the surplus parts of the expression. Each PU has direct access to the entire memory unit and two double-ended queues. Additionally, each PU has four registers for information on the subexpression being traversed, the reduction table which contains the user-defined transition table controlling the evaluation, an action unit performing the actions specified by the reduction table, and the operational story holding the user-defined code for the action unit.

The function of the processing unit is to build up a reducible expression in its buffer register and then rewrite it. Each processing unit can read or write to either of its double-

ended queues. There is a direction register to maintain the current direction. The asynchronous operation of the processing units and their parallel traversal of the expression may present opportunity for deadlock, i.e., two adjacent units may be attempting to reduce simultaneously the same innermost reducible expression. The protocol to resolve this conflict is to allow the processing unit on the right, reading a double-ended queue which is empty, to output its buffer contents and reverse direction. To enforce the protocol, a software package called the reduction table generator, is used to ensure the generation of a consistent reduction table.

The "innermost" reduction scheme proposed by this architecture uses state table and parser generator concepts to generate these tables for user-defined reduction languages. The main problems involve correct condition handling and the bottleneck in the global memory unit.

### Summary

The above-described research in computer architecture is funded under a SERC DCS grant of £ 225K for a period of four years. The grant will terminate in September 1982. It appears that good progress has been made toward a sensible evaluation of the viability of parallel architectures in contrast to the customary approach of devising a general-purpose solution first and then looking for a suitable problem.

Y.S. Wu

ONR London

### PISA—ORIGIN OF COMPUTING RESEARCH IN ITALY

At the Verenna International School of Physicists in 1954, Enrico Fermi urged that a research organization be established to design and construct electronic computers for furthering research in physics. Initial grants were obtained from the cities of Livorno, Lucca, and Pisa, and the Centro Studi Calcolatrici Elettroniche (CSCE) was formed at the University of Pisa in 1955. Subsequent grants from the Italian National Research Council (CNR) and other nuclear-energy-related sponsor organizations supported the development of Calcolatrice Elettronica Pisana (CEP), the first digital electronic computer in Europe. In the mid-1960s it was felt that a research organization was not adequate to serve the computing needs of the university, so the Centro Nazionale Universitario di Calcolo Elettronico (CNUCE) was spun off from CSCE to provide computing services to all universities in Italy. In the early 1970s, CNR acquired both CSCE and CNUCE. CSCE became the Istituto di Elaborazione della Informazione (IEI) to pursue computing science research and exploratory studies. CNUCE took over the charter of

applied research in addition to providing computer services. A new computer science department, (Istituto di Scienza della Informazione) was established in the university at that time. However, the computer engineering curriculum was retained by the electrical engineering department (Istituto di Elettronica). Good collaboration among the institutes is in evidence, but from an outsider's perspective, it is difficult to sort out various activities. In particular, the same researcher may have offices at different organizations in Pisa.

#### IEI

Ever since its inception, CSCE had had a strong leaning toward applied mathematics. The center was formed by the mathematics faculty of the university with engineering support from an industrial firm, Olivetti. This orientation is still evident in IEI. The 100 - person IEI staff is divided into five research areas: applied mathematics and numerical analysis, biomedical engineering, systems architecture, software systems, and non-numerical processing.

In applied mathematics, investigations have been continuing in non-linear systems, hydrodynamics, applied mechanics, and simulations of chemical plants. In biomedical engineering, major efforts are in the automatic processing of electroencephalographic (EEG) data, the construction of an artificial limb for testing human reactions, and simulation studies of neural systems. There are also design studies in progress to produce a pacemaker with reduced power and size; this is being pursued through clinical investigations in collaboration with the medical school of the university, to determine the optimal placing of the electrode in the pacemaker to minimize the required energy.

The most important project in systems architecture and software systems is a multi-microprocessor prototype for designing and testing fault-tolerant operating systems and distributed processing concepts described previously (ESN 35-6:219 [1981]). In addition, interesting work is in progress in programming language. IEI has defined and implemented a self-extensible language that can be used to describe compilers, operating systems, and programs with the aim of achieving machine independence. There have been activities in constructing generalized Markov algorithms to interpret the formal definition of the semantics of programming languages. Switching theory, design automation, and process control researches are conducted in the system architecture group. The non-numerical processing group is doing research primarily on data bases, pattern recognition, and image processing.

#### CNUCE

CNUCE provides data processing service to all CNR institutes and universities in Italy. The center consists of two computers, an IBM 370/168 with 4 megabytes of main storage,

controlled under VM/370 by an IBM 370/158 that runs the operating system VS2. The total auxiliary disk storage available is  $3 \times 10^9$  bytes. The center distributes this processing resource in both interactive and batch modes through a transmission network of 6,000 km of dedicated lines. The switched network consists of 60 telephone numbers, remote concentrators, and multiplexers. The data transmission network is shown in Figure 1.

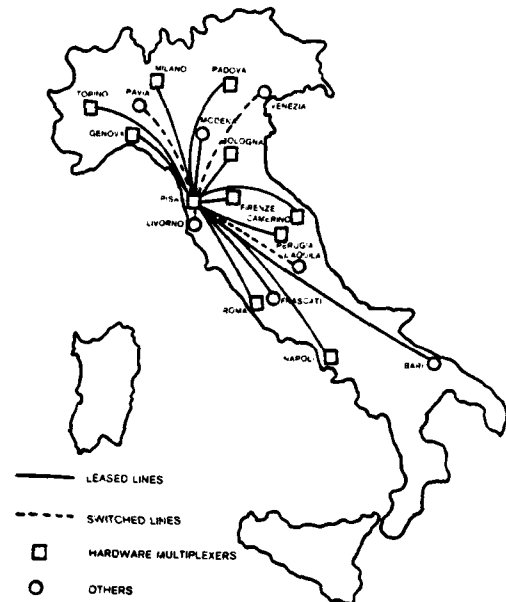


Figure 1

As a natural outgrowth of the above service activity, CNUCE has been conducting research and development in networks for computational resource sharing. A project called Reel Project Computer Network (RPCNET) is underway in collaboration with Comitato Nazionale per l'Energia Nucleare, Bologna; Centro Studi Applicazioni Tecnologie Avanzate, Bari; and universities at Padua, Turin, and Venice. The purpose of the RPCNET is to share software and data bases. There are three areas of activity: implementation of generalized communication systems, definition of network access methods, and devising file exchange mechanisms. In addition, CNUCE conducted a satellite data network experiment for the European nuclear energy community, Stella, in collaboration with Rutherford and Appleton Laboratories, Chilton, UK. This was reported in ESN 36-1:7 (1981). An ARPANET terminal interface processor will be installed at CNUCE in the summer of 1982.

#### Università Degli Studi di Pisa

All computing-related activities in Pisa originated from the university. However, after

the separation of IEI and CNUCE from the university and the formation of Istituto di Scienza della Informazione, the university became a teaching-only institution in computing science. Little research is in progress other than individual faculty participating as team members on IEI or CNUCE projects. In addition, the open admission policy and the popularity of computing science in Italy allows 1,600 students to register as majors with a total staff of only 40 (including part-time IEI and CNUCE lecturers). Faculty members are too busy teaching to have much time for research.

#### Summary

With two major CNR institutes and the university's historical involvement in computing, one can conclude that all computer related activities in Italy have a Pisa connection, or, in other words, a Pisa leaning!

Y.S. Wu

ONR, London

## MATERIAL SCIENCES

### ELECTROCHEMISTRY AT THE UNIVERSITY OF DÜSSELDORF

The University of Düsseldorf is a relatively new institution. It was founded in 1965 as an outgrowth of the Düsseldorf Medical Academy and has grown steadily to its present enrollment of about 10,000 students. The electrochemistry group, which is part of the physical chemistry faculty, is headed by Prof. J.W. Schultze, who, like Prof. H.H. Strehblow, recently moved to Düsseldorf from the Free University of Berlin. The members of the electrochemistry group and their recent research interests are: Schultze (electrosorption, electrocatalysis, and corrosion), M.M. Lohrengel (oxide layers, corrosion, and inhibition), W. Schmickler (electron transfer reactions and bond formation in adsorbates), U. Stimming (photoelectrochemistry, electronic properties of oxide films), and Strehblow (localized corrosion, semiconductor surfaces, photoelectron spectroscopy).

On a recent visit to the university, the author and Dr. J. Kruger of the US National Bureau of Standards spent some time in discussion with Schultze and Strehblow. Schultze spoke about his interest in the effects of the semiconductivity of oxide films on metallic corrosion processes. He recently proposed a semiconductor model for the passive film on iron surfaces. The inner layer ( $\text{Fe}_3\text{O}_4$ ) of the thin passive film has a nearly metallic conductivity, but according to Schultze, the outermost layer of  $\gamma\text{-Fe}_2\text{O}_3$  behaves like an n-type semiconductor, an insulator, or a p-type semiconductor, depending on the electrode potential.

From capacitance measurements it has been possible to deduce the band structure of the passive layer for various ranges of electrode potential. At low potentials, the passive film on iron behaves as a highly doped n-type semiconductor, so that electron transfer reactions occur via the conduction band. With increasing potential, the oxide layer becomes exhausted and behaves as an insulator. Finally, at very high potentials, there is sufficient band bending that the oxide layer acts as a semiconductor again, with valence band participation. Schultze is interested in the effect of such semiconductor oxide films on a variety of electrode processes, such as stability of passive films, electrosorption of organic inhibitors, electron transfer reactions, and tunneling effects.

One of Strehblow's recent interests has been the application of photoacoustic spectroscopy to electrode reactions. The photoacoustic (or optoacoustic) effect has been known since 1881, when Alexander Graham Bell discovered that a periodically interrupted beam of light shining on a solid in an enclosed gas-filled cell produces an acoustic signal. The photoacoustic effect has been used for many years to study relaxation phenomena in gases, but it has been only in recent years, through the work of A. Rosencwaig at Bell Laboratories, that photoacoustic spectroscopy (PAS) has been developed as a technique for studying solids. Strehblow is one of a small number of investigators who has carried this development a step further by applying PAS to the solid-liquid interface.

In conventional PAS of solids, a sample is placed inside a specially designed closed cell containing a suitable gas and is illuminated through a window with chopped monochromatic light. Light absorbed by the solid is converted at least in part by radiationless processes into heat. The resulting periodic heat flow from the solid absorber to the surrounding gas in the cell creates pressure fluctuations that are detected by a microphone.

For in-situ electrochemical applications where the electrode is in contact with electrolyte, the microphone detector and sealed gas chamber are located on the back of the electrode. Heat on the surface of the sample resulting from the photoacoustic effect is transferred through the metal to the rear compartment causing the sealed gas (0.3 cm<sup>3</sup> in Strehblow's cell) to expand. Experimental details are provided in *J. Phys. Chem.*, **85**, 447 (1981).

In recent work at Berlin, Strehblow and co-workers have shown that photoacoustic spectroscopy can be used to detect the in-situ growth of oxide films on copper in 0.1 M KOH. The PAS signals (at constant wavelength) as functions of electrode potential correspond approximately to the current density-potential curve, although the PAS peaks are much broader and not so well defined. However, the first results were sufficiently encouraging that Strehblow intends to continue his work on PAS at Düsseldorf.

Strehblow also plans to resume his previous work on semiconductor surfaces and on the pitting corrosion of metals. In previous studies on telluride semiconductors, he used rotating ring-disk voltammetry to identify soluble reaction species and x-ray photoelectron spectroscopy to determine the composition of the resulting films formed in various electrolytes. Strehblow's work on the pitting of iron and nickel has been concerned with the effect of the chloride ion on pit initiation and with the role of salt films in pit propagation and repassivation.

At the time of the visit, the electrochemistry group was still settling in at Düsseldorf. In view of the obvious abilities and varied interests of this group it is reasonable to expect that exciting and important work will be forthcoming from them.

*E. McCafferty*

ONR Arlington, VA

#### EIGHTH INTERNATIONAL CONGRESS ON METALLIC CORROSION

The 8th International Congress on Metallic Corrosion was held in Mainz, West Germany, September 6 to 11 1981. There were over 750 attendees from 45 countries. One-third (250) were from West Germany, only 29 were from the United States. A surprisingly large number (25) were from the People's Republic of China. The meeting was organized for the International Corrosion Council and the European Federation of Corrosion by DECHEMA (Deutsche Gesellschaft für Chemische Apparatewesen). As was intended by the hosts, it not only served as a vehicle for the transfer of corrosion information but also did much to promote new friendships and to foster informal discussions. The congress president, Dr. H.J. Engell, in his welcoming address reminded the participants of the challenges confronting them. "Corrosion," Engell said, "is not just another pleasant topic. It is dirty, annoying, and expensive."

As in recent congresses (held every 3 years), the discussions covered a broad area. Oral presentations and poster sessions addressed most major aspects of corrosion research as well as a wide variety of practical problems. Research topics included passivity and its breakdown, crevice corrosion, pitting, atmospheric corrosion, high-temperature oxidation, hot salt corrosion, organic coatings, metallic coatings, stress corrosion cracking, and corrosion fatigue. Practical problems concerned the following technological areas: marine corrosion, oil and natural gas winning, power and nuclear industries, chemical process industries, and underground construction and pipelines. There were also sessions on the economics of corrosion and on corrosion education.

The technical program consisted of 10 plenary lectures, some 100 discussion papers, 250 poster papers, and 3 "meet the expert" sessions where questions from the floor were fielded by practicing specialists. In addition, there were panel discussions on the economics of corrosion and on problems involving information retrieval and technology transfer.

A listing of the plenary lectures serves to illustrate the breadth of subject matter of the conference:

"Hydrogen Embrittlement of High Strength Steel by Atmospheric Corrosion" (H.J. Engell, Max-Planck Institut für Eisenforschung, Düsseldorf, West Germany).

"Passivity Breakdown and Pitting" (N. Sato, Hokkaido Univ., Japan).

"Role of Sulphur in High Temperature Corrosion" (S. Mroweć, Academy of Mining and Metallurgy, Kraków, Poland).

"Materials Degradation by Carburization and Nitriding" (H.J. Grabke, Max-Planck Institut für Eisenforschung, Düsseldorf, West Germany).

"Environment-Sensitive Fracture of Metals" (R.N. Parkins, Univ. of Newcastle upon Tyne, England).

"Corrosion of Plastics under Special Consideration of Cracking Phenomena" (G. Menges, Institut für Kunststoffverarbeitung, West Germany).

"Actual Problems in Corrosion Protection" (J. Weber, Gebrüder Sulzer AG, Switzerland).

"Materials Problems in Coal Gasification" (J. Stringer, Electric Power Research Institute, US).

"Active-Passive Transition of Metals" (A.J. Arvia, Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas, Argentina).

"Determination of Corrosion Rates by Electrochemical DC and AC Methods" (W.J. Lorenz, Univ. of Karlsruhe, West Germany, and F. Mansfeld, Rockwell International, US).

The meeting differed from previous congresses in that much of the information was presented in the poster papers. Although the poster sessions provided an opportunity for informal discussion with the various authors, it was troublesome (and tiring) having to pore over so many. There is no substitute for oral presentations where one can hear the points the author chooses to emphasize and to highlight.

Because of the breadth of subject matter, such congresses provide an excellent way to survey progress across the entire corrosion field. The following are accounts of interesting papers from several sessions.

There has been much activity in the field of corrosion control by organic coatings. F. Mansfeld and co-workers (Rockwell International, US) use alternating current (ac) impedance measurements to monitor the penetration of electrolyte into the organic coating and to detect corrosion initiation at the metal substrate. From detailed analysis of Bode plots

(log impedance vs log frequency) an equivalent circuit is established for the system. One component of the circuit is the pore resistance of the coating. Mansfeld has compared the pore resistance for various surface pretreatments and has established rankings for the effectiveness of the pretreatments on the performance of polybutadiene coatings.

M. Piens, J. Hubrecht, and J. Vereecken (Brussels, Belgium) compared measurements of ac impedance and polarization resistance for coated metals. They noted that the polarization resistance (i.e., polarization behavior near the corrosion potential) of coated metals includes both the charge transfer resistance and the resistance of the coating (and also depends on scan rate). They believe that ac impedance measurements are more complete because the effects can be separated.

In related work, J.D. Scantlebury and colleagues (Univ. of Manchester Institute of Science and Technology, UK) presented an interesting poster on impedance measurements using a novel cell design in which the generator and detector are on the same side of the paint film.

J. Kruger and J. Ritter (National Bureau of Standards, US) have used ellipsometry in conjunction with electrochemical measurements to study subcoating environments. They observed several stages in the degradation of collodion coatings on iron. The stages are pH increase under the coating due to oxygen reduction, roughening of the metal surface, growth of the subcoating metal oxide film, and possible chemical changes in the organic coating due to the high pH.

Crevice corrosion attracted much interest in one of the poster sessions. Posters presented various aspects of crevice corrosion processes, including electrode kinetics, thermodynamics, surface analysis, and local solution chemistry.

S. Zakipour and C. Leygraf (Royal Institute of Technology, Stockholm) used Auger spectroscopy to study the surface composition of locally corroded austenitic stainless steels. The surface composition of crevice corroded areas was different from the bulk alloy composition and was affected by the composition of the crevice electrolyte. Crevice corroded surfaces were enriched in Cr (due to preferential dissolution of iron) and in Mo and Cu (due to deposition as metal sulfides following dissolution of sulfide inclusions).

J.H. Drugli and co-workers (The Engineering Research Foundation at the Technical University of Norway) measured polarization curves in 3% NaCl to determine propagation rates of crevice corrosion. The approach assumes that the anodic reaction occurs within the active crevice and nearly all the cathodic reaction occurs at the passive outer surface. Cathodic polarization curves depended on immersion time, and the appropriate curves were determined after 44 days of free immersion.

S. Bernhardsson and co-workers (Sandvik Group, Sweden) have developed a mathematical model for the initiation stage of crevice corrosion. The model, which involves transport processes coupled with chemical equilibria, was used to calculate the crevice pH and chloride ion concentration. A characteristic variable in determining the crevice electrolyte chemistry was found to be the crevice severity, defined as  $(\text{corrosion current density}) \times (\text{crevice depth})^2 / (\text{gap width})$ . The calculated crevice pH decreases with increasing crevice severity and with increasing bulk chloride concentration.

A combined kinetic and thermodynamic approach was taken by A. Pourbaix and W. Yang (Centre Belge d'Etude de la Corrosion, Brussels) to investigate the effect of Mo on the localized corrosion of stainless steels. They attribute the beneficial effects of Mo to the formation of a protective film of  $\text{MoO}_2$ . This interpretation is based on Auger analysis of pure molybdenum surfaces that were immersed in artificial crevice solutions. In addition, the region of passive behavior of Mo in such crevice solutions is in good agreement with the thermodynamic region of stability of  $\text{MoO}_2$  according to the Pourbaix diagram. In the opinion of the authors, the role of Mo is similar in Mo-bearing stainless steels. The presence of Cr retards the initiation of localized corrosion, but when chromic ions hydrolyze to decrease the pH, the protective effect of  $\text{MoO}_2$  becomes important.

In the field of high temperature oxidation, M.J. Graham (National Research Council, Canada) gave a well-organized presentation on the use of Mössbauer spectroscopy. Graham began with some background on the standard Mössbauer spectra characteristic of metallic iron and the various iron oxides and then discussed how more complicated spectra are resolved into those of the constituent oxides. He presented his group's recent work on the thin-film oxidation of Fe-26Cr as studied by Mössbauer spectroscopy in conjunction with electron diffraction and Auger analysis. The initial oxide that forms on Fe-26Cr on heating to 600°C in  $5 \times 10^{-3}$  Torr  $\text{O}_2$  is a duplex layer ( $\sim 300 \text{ \AA}$ ) of  $\text{Fe}_3\text{O}_4$  on  $\gamma\text{-Cr}_2\text{O}_3$ . After 1 min,  $\alpha\text{-Fe}_2\text{O}_3$  nucleates on  $\text{Fe}_3\text{O}_4$ . After 4.5 h,  $\text{Fe}_3\text{O}_4$  is converted to  $\alpha\text{-Fe}_2\text{O}_3$  and  $\gamma\text{-Cr}_2\text{O}_3$  to  $\alpha\text{-Cr}_2\text{O}_3$ . The extent of incorporation of Cr into  $\text{Fe}_3\text{O}_4$  or  $\alpha\text{-Fe}_2\text{O}_3$  is small.

G.J. Yurek (Massachusetts Institute of Technology) reviewed his interesting work on the oxidation behavior of fine-grained, rapidly solidified (and consolidated) 303 stainless steel. The resistance to cyclic oxidation of the rapidly solidified alloy in pure oxygen at 900°C is superior to that of the conventional 304 stainless steel. (The two alloys have similar Cr and Ni contents, i.e., 18-8, although 303 contains more S.) The improved oxidation resistance of the rapidly solidified alloy is attributed to the fine grain size and to the presence of uniformly dispersed, very fine MnS particles. An improved scale adherence is attributed to oxide



pegging along the closely spaced grain boundaries and around MnS particles.

Two volumes of the congress proceedings had already been published and were available at the congress. A third volume containing the plenary lectures is forthcoming. The Ninth International Congress on Metallic Corrosion will convene in Canada in 1984.

*E. McCafferty*

ONR Arlington, VA

#### METAL SPRAYING AT UNIVERSITY COLLEGE-SWANSEA

Prof. A.R.E. Singer and his colleagues at the University College of Swansea have conducted research since the late 1960s on novel manufacturing processes wherein bulk objects are built up by metal spraying. Singer's primary aim has been to devise and develop processes that would give manufacturers a more direct route from crucible to finished product, thereby eliminating many of the expensive and wasteful intermediate steps necessitated by conventional processing. At the same time, he has not been unaware of other potential benefits, such as minimized segregation or extended solid solubility, that the rapid solidification associated with metal spray processing can impart to the solidified product.

Spray rolling was the first technique investigated by Singer in 1968. In the method, molten metal is atomized into droplets by nitrogen or by an inert gas and projected onto a cool substrate, usually a movable strip, where it is rapidly solidified. By using sprays of high density and by moving the substrate, strips as thick as several inches can be built up. The strips are subsequently removed from the substrate for further processing by rolling. Initially, aluminum alloys were processed; the investigation demonstrated that spray rolling was indeed a viable technique and that the fine grain size and little, if any, segregation in the product were apparently inherent to the process and decided advantages. For example, Al-Cu alloys with as high as 6% Cu could easily be rolled when made by spray rolling, something that was impossible when the alloy was conventionally processed. The spray rolling process has since been developed further by industry. One manufacturer, Aurora Steels Ltd., has a development plant currently in operation capable of continuous spray rolling in batches of up to 2 tons. They have spray rolled material up to 4 in. thick and are of the opinion that thickness need not be a limiting factor for the process. Aurora has concentrated on high-speed tool steels, which are particularly difficult to process conventionally and prone to

carbide segregation. They claim that, when spray rolled, these steels exhibit little segregation and have enhanced mechanical properties.

Spray forging is another process devised at Swansea that is now being developed further by an industrial firm, Osprey Metals Ltd., a firm started by several former members of Singer's research team. The process is designed for making forging preforms. It consists of spraying molten droplets of metal into a cooled mold with the desired preform shape. The mold is then stripped and the part is finish forged to shape. A drawback to the process is that the higher density of droplets in the center of the spray produces a crown in the center of the back of the preform that must be removed prior to final forging. The crown effect inherent to stationary spraying processes can be eliminated, of course, by manipulation of the spray or substrate, with concomitant increases in process complexity and cost of the product. So far, aluminum alloy, steel, and high-temperature alloy preforms have been produced for assessment.

Spray casting, currently being explored by Singer, is quite similar to spray forging, but the mold used is considerably more intricate. In addition to problems brought about by non-uniform spray density, other problems such as gas removal must be overcome.

Centrifugal spray casting has been investigated for forming tubes. Two approaches for transferring the molten droplets to the tubular substrate have been studied. In the first, a stream of metal impinging on a disk rotating at 3,000 to 5,000 rpm is directed to the wall of a tube concentric to the disk. In the second method, the liquid metal is formed by a centrally located arc. The consumable electrode, made of the alloy to be deposited, is rotated and the liquid droplets are sprayed to the concentric tube substrate. As gas for atomization is unnecessary in centrifugal spray casting, tubes of highly reactive materials like titanium could be processed by the method, but, so far, only aluminum, steels, and high temperature alloys have been used. Short tubes of these materials have been produced with diameters up to 16 in. and with as-cast properties that compare favorably with those of conventionally processed materials.

Spray coating of one metal with another is of great interest to the group at Swansea, and it currently has a contract with Ford Motor Company to look into the feasibility of spray coating for producing steel sheet galvanized or aluminized on one side for corrosion protection. The group is now operating a small pilot plant for continuous coating of 10-in.-wide strips. The steel strip is first heated for a short time at 800°C in a reducing atmosphere prior to spraying on one side; the limited time at temperature for the coated strip prevents the formation of brittle intermetallic compounds at the coating-steel interface. Because of the spray pattern, coating thickness must be

greater than 0.001 in. for adequate coverage. In addition to this work, Singer is interested in investigating the spray coating process further by coating one side of steel with copper and copper-nickel alloys for possible structural application where fouling resistance is important.

Metal matrix composites made by spraying have been among Singer's interests for the past several years. His research with these materials has been devoted to frictional and wear applications, and he has investigated composites such as Al-SiC, Al-Al<sub>2</sub>O<sub>3</sub>, Al-SiO<sub>2</sub>, and Al-graphite. With composites such as these, where matrix and particles differ significantly in density, much research was necessary to find the best method for dispersing the particles to prevent gravity segregation during spraying. The method finally developed consists of injecting the particles in a cyclone pattern concentric with the liquid metal stream and the gas stream used for atomization. This results in solidified material with a surprisingly uniform distribution of particles, and solids with reasonably good frictional properties have been produced. For example, the coefficient of friction of a composite of Al(5%Si)-13.5% SiC (10- $\mu$ m particle size) rubbing dry against cast iron was 0.5 in comparison to 0.3 to 0.4 for bonded asbestos material, and the coefficient remained quite constant with time.

Singer's most recent interest is in spray peening. In this technique metal spraying is carried out as in the spray rolling or spray coating methods, but simultaneously with the spraying the deposits are peened. He has deposited both flat and tubular shapes by the method. The apparatus currently used consists of an enclosed chamber with an arc gun for melting. Atomization and spraying is done with nitrogen. Peening is done by means of a mechanical ball slinger and 3-mm diameter steel balls (actually reject ball bearings) propelled at velocities that can be varied from 5 to 100 m/s; generally, low velocities are used. After the balls impact on the deposit they are automatically collected and returned to the slinger via a gas trap. The spraying and peening processes do not interfere with one another significantly. Any deposit on the balls usually falls off during their return passage to the slinger.

According to Singer, spray peening has four advantages over conventional spraying: the deposit is incrementally hot-worked, which leads to grain refinement throughout the deposit; porosity is greatly reduced (in unpeened as-sprayed deposits porosity ranges from about 2 to 4%) and may in fact be completely eliminated, making subsequent densification processing unnecessary; peening increases the cooling rate of the deposit through additional heat extraction by the balls; the residual stress pattern in the deposit can be altered to reduce harmful tensile stresses. He believes the last-named advantage could be especially important in spraying for tools and dies, because in such applications high internal stresses

developed during conventional spraying often result in distortion and cracking. He also believes that the higher heat transfer capabilities of the process might make the method capable of producing rapidly solidified microcrystalline materials. As is well known, a great deal of interest currently exists in these materials, but, except for some laser processing methods, powder metallurgy techniques seem to be dictated for their production and/or consolidation. After a visit to Singer, however, one comes away with the feeling that the spray techniques he is advocating may indeed have much to offer in the rapid solidification regime. They certainly are well worth considering.

*Philip A. Clarkin*

ONR London

## MATHEMATICS

### USING ASYMPTOTIC EXPANSIONS TO FIND APPROXIMATE CONFIDENCE INTERVALS

A common problem in statistics is that of making inferences about unknown parameters of a member of an assumed distribution family based on a sample,  $X_1, X_2, \dots, X_n$ , of observations from that population. Often this concerns estimation of a parameter  $\theta$ , either with a point estimator  $\hat{\theta}(X_1, X_2, \dots, X_n)$  or an interval estimator  $[L(X_1, \dots, X_n), U(X_1, \dots, X_n)]$ . The interval estimator is usually required to have the property that, whatever be the value of  $\theta$ , the probability that  $\theta$  will be captured between  $L$  and  $U$  is some prespecified "confidence level,"  $1-\alpha$ . If that is not feasible, the statistician might have to settle for a coverage probability that is approximately  $1-\alpha$  or is at least  $1-\alpha$ , depending on the application. An interval procedure having coverage probability that can be guaranteed only to be approximately  $1-\alpha$  is called an approximate interval estimator; a realization (an actual computed interval, based on observed data) is called an approximate  $(1-\alpha)100\%$  confidence interval. In some applications, the parameter  $\theta$  (or parameters) is considered to be a random variable (or vector) having some prior distribution representing the statistician's knowledge about  $\theta$  before data are observed. Observed data are used to update the information by forming the posterior distribution of the parameter, given the data. Such a model is called a Bayesian model. In some applications involving Bayesian models, it is desired to find values  $L$  and  $u$  such that the posterior probability that an outcome on  $\theta$  will fall between  $L$  and  $u$  is, or is approximately, a prespecified value  $1-\alpha$ . Such an interval  $(L, u)$  is called a  $(1-\alpha)100\%$  prediction interval for  $\theta$ .

A simple illustration of these ideas can be given in a reliability context. Suppose  $n$  items (such as electronic components of a certain type) are to be put on test at time zero and

the times  $X_1, X_2, \dots, X_n$  at which each fails are to be noted. Suppose the time to failure of such an item is thought to be exponentially distributed with unknown parameter  $\lambda$ ; that is,  $P[X_i \leq t] = e^{-\lambda t}$ , where  $\lambda > 0$  is unknown, and suppose the failure times are independent. The usual point estimator for  $\lambda$  is  $\hat{\lambda} = 1/\bar{X}$  where  $\bar{X}$  is the mean failure time of the  $n$  items. Since  $2n\lambda\bar{X}$  has a known distribution (chi-square with  $2n$  degrees of freedom), it is easy to find  $l$  and  $u$  such that  $P[l/2n\lambda\bar{X} < u/2n\lambda\bar{X}] = 1-\alpha$ , that is,  $P[l/2n\bar{X} < u/2n\bar{X}] = 1-\alpha$ , so an exact  $(1-\alpha)100\%$  random interval for the mean time to failure ( $MTTF=1/\lambda$ ) of these items is  $(2n\bar{X}/u, 2n\bar{X}/l)$ . Bayesian prediction intervals are also readily found in this context for certain prior distributions.

There are several approaches to finding confidence intervals. A common method is to find a function  $H$  of  $\hat{\theta}$  and  $\theta$  whose distribution does not depend on  $\theta$ , so  $l'$  and  $u'$  can be found such that  $P[l' < H(\hat{\theta}, \theta) < u'] = 1-\alpha$ . Now (with a little luck) the event in this expression can be "inverted" to give an equivalent event  $[L < \theta < U]$ . This was the method used in the example above. There can be several difficulties with this approach. One is in finding a function  $H$  such that the inversion can be carried out. Another is in finding the distribution of  $H(\hat{\theta}, \theta)$ , so  $l'$  and  $u'$  can be obtained. Sometimes functions  $H$  are found so the asymptotic distribution of  $H(\hat{\theta}, \theta)$  is known; for finite sample size use of the asymptotic distribution yields approximate confidence intervals. An example of this is the use of a function of the form  $(\hat{\theta}-\theta)/\sigma(\hat{\theta})$ , which estimation theory associated with the form of  $\hat{\theta}$  may guarantee is asymptotically standard normal. Then approximate  $l'$  and  $u'$  values are readily available from the asymptotic distribution and the inversion is easily carried out to give an approximate interval.

If convergence to normality is slow or if sample size is small, the asymptotic procedure described above may lead to poor approximations. That is, the actual coverage probability of the approximate interval may differ substantially from the desired value,  $1-\alpha$ .

Alan Winterbottom, acting chairman of the Department of Mathematics at the City University, London, has developed a method for finding approximate confidence intervals that he claims often have good performance, even when  $n$  is small. The method is based on asymptotic expansions for the percentiles of a distribution developed by Cornish and Fisher. It involves formulation of a normalizing polynomial transformation that can be inverted to give an asymptotic expansion for confidence limits. Normalization of the polynomial is obtained by equating low order cumulants to those of a normalizing polynomial transformation derived from the Edgeworth expansion of the distribution function. (Cumulants, the coefficients of  $(t^r)/r!; r=1,2,\dots$ , in the power series expansion of  $\ln \phi(t)$ , where  $\phi$  is the characteristic function, are used because they are

more tractable than moments. For example, they are invariant under changes in location [for  $r > 1$ ], in sharp contrast to moments.)

An illustration of the use of Winterbottom's procedure can be given in the context of finding a confidence interval for the bivariate normal correlation coefficient,  $\rho$ . Let  $R$  denote the sample correlation coefficient, based on a random sample of size  $n+1$ , and let  $h(t) = (1/2)\ln[(1+t)/(1-t)]$ . Let  $Z=h(R)$  and  $\zeta=h(\rho)$ , so  $\sqrt{n}(Z-\zeta)$  is asymptotically standard normal, as is well known. But using this to find confidence intervals for  $\zeta$ , and hence  $\rho$ , can lead to poor approximations when  $n$  is small. Substituting cumulant coefficients into the Cornish and Fisher form of the Edgeworth expansion for a distribution function, Winterbottom obtains an expression of the form  $F(z, \zeta) = \Phi(x) - \phi(J)$ , where  $\Phi$  is the standard normal CDF,  $\phi$  is the standard normal density,  $J$  is a truncated series involving the cumulant coefficients and Hermite polynomials, and  $x = \sqrt{n}(z - \zeta)$ . Through the relationships between  $(z, \zeta)$  and  $(r, \rho)$  this can be used to obtain approximate percentiles of the distribution of  $R$ . To obtain approximate confidence intervals for  $\rho$ , Winterbottom considers the polynomial random variable, obtained through considerations of its cumulants,

$$y = -\frac{r}{2n} - \frac{r(3+r^2)}{12n^2} + \left[1 - \frac{1+r^2}{4n} + \frac{3-11r^4}{96n^2}\right](z-\zeta) + \left[\frac{r(3-4r^2)}{24n}\right](z-\zeta)^2 + \left[\frac{-1}{12} + \frac{2+7r^2-6r^4}{48n}\right](z-\zeta)^3 + \frac{3}{160}(z-\zeta)^5$$

Then  $\sqrt{n}y$  becomes a standard normal variate to a much better approximation than  $\sqrt{n}(z-\zeta)$ . This polynomial can also be used to approximate the CDF of  $R$ ; given  $n, r$ , and  $\rho$ ,  $\sqrt{n}y$  can be calculated and  $\Phi(\sqrt{n}y)$  approximates  $F(r, \rho)$ . The polynomial form above can be inverted, yielding an asymptotic approximation for confidence limits. This yields the following confidence limit expansion for  $\zeta$ :

$$\zeta(x) \approx z + \frac{x}{\sqrt{n}} - \frac{r}{2n} + \left[x^3 + 3(1+r^2)x\right]/12n^{3/2} - \left[4r^3x^2 + 5r^3 + 9n\right]/24n^2 + \left[x^5 + (60r^4-30r^2+20)x^3 + (165r^4+30r^2+15)x\right]/480n^{5/2},$$

where  $x$  is an appropriate standard normal quantile corresponding to the desired confidence

level. The related confidence limit for  $\rho$  is then  $\rho = \exp(2\zeta) - 1 / \exp(2\zeta) + 1$ . Winterbottom has shown that this gives good approximations, even for sample sizes as small as 10.

In a recent visit with Winterbottom, he informed the author that he is now working on the use of this asymptotic expansion method for Bayesian models in reliability applications. He plans to develop first and second order corrections to the large sample formulae for approximating percentage points of system reliability posterior distributions. Winterbottom says he hopes to carry this out for systems configured in accordance with general structure functions, including the possibilities of systems with spares and active redundancies.

Donald R. Barr

ONR London

## NEWS AND NOTES

### COMPACT CARDIOGRAPH

A new heart-monitoring device, produced by a joint effort of Edinburgh University and Reynolds Medical Ltd. (UK), can record cardiographic information for a continuous 24-hour period. The machine, which is extremely lightweight, employs a slow-running standard C-90 cassette tape. For automatic analysis and detection of irregularities, the tape can be run through a modem and into a minicomputer. The most advanced feature is reportedly the electronically controlled tape-drive system, which reduces power so that the recorder will run for a whole day on a 9-volt battery. Later versions of such recorders may incorporate a special computer chip. Such an addition could provide various kinds of monitoring and condition displays to the wearer, and would offer the opportunity for various levels of software complexity.

As an even more intriguing possibility, John Barker at Warwick University (Coventry, UK) is now working on a tiny "biochip" that would sense ionic changes in an active heart and send signals regarding these changes to a display or transmitter device.

Nicholas A. Bond, Jr.

ONR London

### CARBON MONOXIDE RATHER THAN NICOTINE?

Research suggests that nicotine is a main addictive constituent in tobacco smoking; for example, nicotine chewing gum that delivers a small and slowly absorbed dose through the lining of the mouth is one of the most effective antismoking aids (ESH 35:12 [1980]). Furthermore, cigarettes without nicotine have never

been a commercial success, and smokers often use more reduced-nicotine cigarettes if they are forced to smoke them.

Experts also agree that inhaled tar is the main culprit in smoking-caused lung cancer. But studies at the cancer epidemiology unit, Radcliffe Infirmary, Oxford (UK) indicate that it may be the carbon monoxide in tobacco smoke, rather than the tar or nicotine, that damages the heart. The unit started with the health statistics on smoking and heart disease; it has been known for a long time that pipe smokers suffer little if any more risk of heart disease than nonsmokers, but cigarette smokers run a much higher risk. Depending on age and other factors, a heavy cigarette smoker may have a heart attack expectancy five or ten times that of a nonsmoker or pipe smoker. (If the smoker is a male "Type A" personality, the risk will be even greater, according to data from Friedman and Rosenman at St. Joseph's Hospital in San Francisco.)

The Oxford researchers took blood samples from a sample of pipe smokers, cigar smokers, and cigarette smokers; carbon monoxide and cotinine (nicotine-derived) levels in the blood were measured. Pipe smokers had the highest cotinine levels (389 nanograms per ml) compared to 306 and 121 for cigarette and cigar smokers, but the carboxyhemoglobin level (attributable to carbon monoxide) in the cigarette users was 4.7 %, while cigar and pipe smokers registered 2.9 and 2.2 %, respectively. The measurements are consistent with the idea that pipe smokers do not inhale so deeply as cigarette smokers, but they do absorb more nicotine through the mouth. Another consonant fact is that in cohorts of patients with heart disease, there is a substantial correlation between carbon monoxide in the blood and the severity of the heart disease.

It remains possible that some smoke constituent other than carbon monoxide is the "real" correlate of heart disease in smokers, but the evidence is already strong enough to encourage the publication of official carbon monoxide figures for each brand of cigarettes, and the British health services will start requiring them before long. Canadian laboratory tests show an extremely wide range of CO yields, with numbers from 2.5 to 19.5 milligrams per cigarette. As manufacturers have shown that they can control and gradually reduce tar levels, they probably can reduce CO delivery also. Because heart disease is so much more prevalent than lung cancer, the base rates indicate that even small changes in cigarette CO delivery might save thousands of lives per year.

Nicholas A. Bond, Jr.

ONR London

### RESCUE KITE

In emergencies at sea, detection of lifeboats by sight or by radar can be difficult because of sea clutter. A new "Life Kite" made by Stewkie Aerodynamics Ltd., Dorset, UK permits a radar reflector to be flown at altitudes above 100 meters. The kite is made of polyurethane; when inflated with helium from a self-contained cartridge, it rises immediately and will fly in winds from force one to force nine. Once inflated, it reportedly will not need reinflation for at least 48 hours. The Kite's integral reflector uses a hexagonal mesh optimized for X-band radar; sea trials suggest that radar reflection efficiencies are high, and that the target can be tracked from many miles. To facilitate visual detection, the kite is painted with Dayglow and has a Beta light for night illumination. The weight of the whole package is less than seven pounds.

*Nicholas A. Bond, Jr.*

ONR London

### COGNITION IN DEEP OXYHELIUM DIVES

When breathing air at a pressure equal to that of the water, a diver cannot work much deeper than 60 m; below that point, the operator is in great danger. If a mixture of helium and oxygen is breathed, the diver can go to much greater depths; in fact, over 10 years ago it was reported that subjects in a simulated 1,000-ft oxyhelium dive showed no deficits in memory and figures tests. Later work showed that a human breathing either oxyhelium or a neon-oxygen mixture suffered little or no decrement in measures of arithmetic ability, strength, and complex reaction time when in simulated pressures of 360 m of seawater (msw).

The pattern of performance results at depth was not clear-cut, however; one finding from the mid-1970s was that the more complex tasks seemed to be the ones most affected, and there were other studies showing decrements. The Admiralty Marine Technology Establishment (AMTE) at Alverstoke (UK) has been doing some thorough research on the effects of deep oxyhelium dives on humans. Many hematological, physiological, and biochemical measurements are made during long (18 to 26 days) exposures to the oxyhelium chamber. For present purposes, we refer only to the psychological performance tests to questionnaire responses to 18 bipolar adjectives describing "mood," and to questions about sleep quality. These psychological investigations were reported by Alan Baddeley and Vivien Lewis at the Medical Research Council Applied Psychology Unit, Cambridge University (UK). Dives were at 300, 420, and 540 msw. Subjects for the 300 and 420 conditions were young male AMTE employees; for the 540 msw dive, two commercial male divers served as subjects.

The accuracy of addition of columns of 2-digit numbers was significantly worse at depth as were Stroop color naming, number similarity identification, semantic processing, and visual search for a few word or letter targets in a display. On the other hand, grammatical reasoning and paired-associate memorizing of numbers with words were not seriously affected by depth. The pattern of findings leads to Baddeley's recommendation that instead of a simple generalized decrement, depth conditions can produce a rather specific decrement profile. Among the tests that seemed most susceptible to depth was semantic processing, wherein the subject is required to check rapidly the truth of "common-sense" sentences. This indicates that at depth, a subject can be expected to have trouble accessing old information. The point deserves further investigation, because in practical work, divers are expected to use their technical skills.

Rated sleep and mood were both influenced by compression, but the sleep decrement seemed to be much more precipitous, with sleep quality scores at depth being only about half as good as those at the pre-dive and post-dive periods. "Alertness" self-ratings were surprisingly high, with no substantial difference between depth and decompression periods on that variable. Changes in "tranquility" scores were also not very susceptible to depth. Correlations between all the different scores were mostly insignificant; perhaps this result should have been anticipated, because of the small numbers of subjects and the reliability of some of the measurements.

The AMTE project is one of the best sources of data on the performance and medical effects of deep dives. It is interesting that, at the same time that more is known about the human factors of deep dives, unmanned submersibles are becoming more sophisticated, with the prospect that some of the work formerly done only by humans can now be done by remotely controlled vehicles.

*Nicholas A. Bond, Jr.*

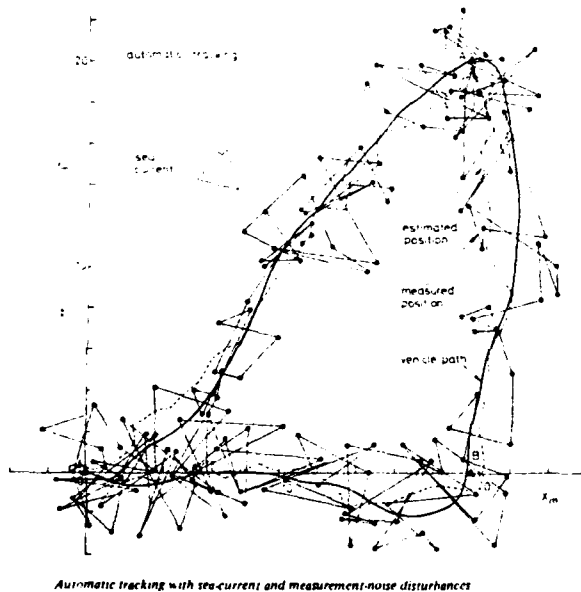
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### AUTOMATIC GUIDANCE OF AN UNMANNED SUBMERSIBLE

Unmanned submersibles are widely used in petroleum and other offshore operations. Such vehicles may be used for routine underwater inspection of structures and seals, or they may be employed on a grid-type search over a large area. The vehicles are often powered by electric motors that are connected through several hundred meters of cable to a support vessel. Acoustic ranging devices can estimate the range and bearing of the submersible from the support ship. The control problem is to

deliver signals to the propellers on the vehicle such that a desired path can be followed. There are several vehicular non-linearities in the submersible's dynamics, and other disturbances such as sea current.

At Heriot-Watt University in Edinburgh, Professors G.T. Russell and J. Bugge have developed and tested a reduced-order control model which does not require precise covariance estimates over the process noise and the measurement noise. An expression for estimated position of the vehicle is adaptive so as to yield the minimum tracking error and to be correctable for sea-current bias. The simulator plot below shows good control of the system around a triangular course. According to the authors, successful sea trials of the control system were also completed in 1981.



Nicholas A. Bond, Jr.

ONR London

#### SUBSEA INVADERS

Marconi Avionics Ltd (UK) has produced a TV-game type trainer for NIMROD ASW crew members. Dubbed the Airborne Crew Trainer Mark 1 (ACT-1), the unit enables an operator to insert simulated submarine position and course data, along with the sonobuoy representations related to that target. The prime ASW equipment (AQS 901) aboard the NIMROD aircraft then operates as it would in a real submarine search attempt, so that realistic practice can be achieved. The ACT-1 operator can put his "submarine" through evasive maneuvers as the trainee attempts localization and classification. This is one of the first ASW

training packages that can activate airborne equipment in a realistic mode. It could easily be used during the dead transit time from base to patrol area. The game-playing feature wherein the training operator attempts to outwit his fellow ASW crewmen may have good motivational effects, and the practice problems can be calibrated for such aspects as difficulty, threat likelihood, and so on.

Nicholas A. Bond, Jr.

ONR London

#### GNRL STAFF CHANGES

We said farewell recently to Dr. Philip Fire and Dr. John Neighbours, who had been liaison scientists at ONR London since January 1980. Dr. Neighbours returned to his post as professor of physics at the Naval Postgraduate School in Monterey, California. Dr. Fire went back to GTE Sylvania Electronics Systems Laboratories, Mountain View, California, where he is a senior scientist. In January, we welcomed liaison scientist Dr. Donald R. Barr, who is on leave from his post as professor of statistics and operations research at the Naval Postgraduate School.

#### ONR COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

General Conference on Condensed Matter, Univ. of Manchester, UK, 22-25 March 1982.

Symposium on Halide & Other Non-Oxide Glasses, Cambridge, UK, 23-25 March 1982.

International Conference on Forward Swept Wing Aircraft, Univ. of Bristol, UK, 24-26 March 1982.

Conference on Optical Techniques in Magnetic Resonance, Hull, UK, 31 March - 2 April 1982.

International Meeting on Lithium Batteries, Rome, Italy, 27-29 April 1982.

International Meeting on Analysis of Sample Survey Data & Sequential Analysis, Jerusalem, Israel, 14-18 June 1982.

IXth IUPAC Symposium on Photochemistry, Univ. of Pau, France, 25-31 July 1982.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

<u>Visitor</u>	<u>Affiliation</u>	<u>Navy Lab./Org. to be Visited</u>
Dr. J.C. Bennett	Dept. of Electronics and Elec. Engr., Univ. of Sheffield, UK	NOSC, San Diego (March or April 1982)

**ONRL REPORTS**

C-12-81

The Biological Effects of Nonionizing Radiation, by J. B. Bateman

This is a critical report on the L.H. Gray Memorial Conference held in Oxford, 13-16 July 1981. The Conference was entitled "Biological Action of Radiofrequency, Microwave and Ultrasonic Radiations." The report provides a background identifying the field of interest in broader terms, intended for the general reader. It is then pointed out that the conference was mainly directed toward research and practice related to the possible value of nonionizing radiations in cancer therapy. There were, however, tutorial lectures of a fairly general character and some discussion of biological effects not necessarily arising from production of heat in irradiated tissues.